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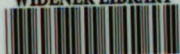
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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 60.

DIVISION OF ANIMAL HUSBANDRY.

JULY, 1898.

BEEF CATTLE AND SWINE.

1. GROWING BEEF IN MINNESOTA.
 2. FATTENING RANGE STEERS IN WINTER.
 3. FEEDING PIGS OF DIFFERENT GRADES.
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BEEF CATTLE AND SWINE.

THOMAS SHAW.

This bulletin contains three experiments. The first of these relates to growing beef, the second to the fattening of range steers and the third to growing pork.

GROWING BEEF IN MINNESOTA.

SECTION NO. 1.

The opinion has heretofore been held by many in our State that beef cannot be grown at a profit on the average farm of Minnesota. To so great an extent has this view prevailed, that it has doubtless virtually hindered numbers from making the attempt to grow it. This opinion was largely grounded on the fact that farther west on the ranges the pastures are free, and that therefore it was an impossible thing to grow beef on an arable farm in which considerable capital had been invested, in competition with beef grown on free pasture. To so great an extent has this opinion prevailed, that it has even been voiced on the public platforms by the teachers of the people. It was not unnatural, therefore, that those who tilled the soil should settle down to the conviction that beef could not be grown at a profit in our State. The writer never sympathized with such a view, and this experiment was undertaken to ascertain, if possible, which was the correct view.

Plan of the Experiment.—In planning the experiment it was proposed to take two calves at birth, to feed them freely on suitable farm products, under the same conditions until nearly two years old, and then to push them to a

finish so that they should be put upon the market at an age not beyond 30 months. The food fed was to be such as any farmer could grow, and the care and management were to be of a character that would be easy of imitation by any farmer or by any farmer's boy. A larger number of animals would have been reared thus could suitable representatives have been obtained at the time.

Autumn Calves Chosen.—It was determined to choose autumn rather than spring calves and for the following reasons: 1. When the calves are dropped in the fall the cows are in milk at a season when the milk product is relatively more valuable than in the summer; 2, calves coming in the autumn can be better cared for during the milk period, that is to say, during the most critical period of growth in the life of the calf, for the grower is not pressed with labor at that season of the year as he is in the summer; 3, the calves are in fine condition to go out on the grass as soon as it is ready in the spring, since before the arrival of the grass they are already weaned, and food so palatable should keep them growing right along in good form; 4, they may enter the following winter in fine shape and can, in consequence, be wintered at less outlay relatively than calves dropped in the spring; and, 5, they are at a suitable age for being marketed in the late winter or early spring when meat is relatively dear.

It was also decided that calves should be chosen, which, in breeding would be the offspring of grade cows of good milking qualities, that is to say, the calves of dual purpose cows, sired by a purely bred beef bull. It was not easy to get such calves, owing to the extent to which dairy bulls prevailed in the neighborhood, and indeed in nearly all parts of the state. Mr. H. F. Brown, of Minneapolis, at length came to the rescue, and presented us with a pair of steer calves in the autumn of 1895. Both of these were out of dams that in breeding were essentially grade Shorthorns. One had a dash of Jersey blood, and both were good milkers.

The respective sires were pure Shorthorn bulls belonging to Mr. Brown's herd.

Description of the Animals.—The two steers were named "Jack" and "Prince" respectively. The former was dropped August 1st, 1895, and the latter September 28th following. Both were essentially of the parallelogramic outline, and both were possessed, but not quite equally, of what may be termed the essential features of the beef form in at least a fair degree. Both were a little leggy as will be apparent from the accompanying sketches. Neither was sufficiently blocky for making the highest type of the beef steer, otherwise Jack had what might be termed good all round development. Prince was somewhat inferior to Jack in width and in roundness of spring of rib. The ribs of the latter bore some testimony to the Jersey blood in the ancestry on the dam's side. They had a medium downward pitch, were a little open spaced, especially toward the rear, and were more plainly apparent to the eye when viewed from the side. As is generally known, those features in rib development are not in keeping with the very highest type of beef production. And just here it may be mentioned that the disadvantage at which this steer was placed because of his less perfect conformation did not seem to militate against his growth. It was more especially during the forcing period at the finish that he lost ground, and on the block he was not, in some respects, quite the equal of the other. In other words it would seem to be true, that want of highest excellence in beef type does not hinder development so much during the growing period as during the finishing period, and that the lack of ability in such animals to make pounds of gain is of less consequence to the grower than the lack of quality in the meat, which compels its sale at a lower price.

Foods Fed.—The foods fed were new milk, skim milk, meal, hay, soiling food, ensilage, pasture and field roots. The skim milk was obtained from the dairy and fed while it was yet warm, that is to say, soon after it had been



Fig. 1. Jack When Ready for the Block.



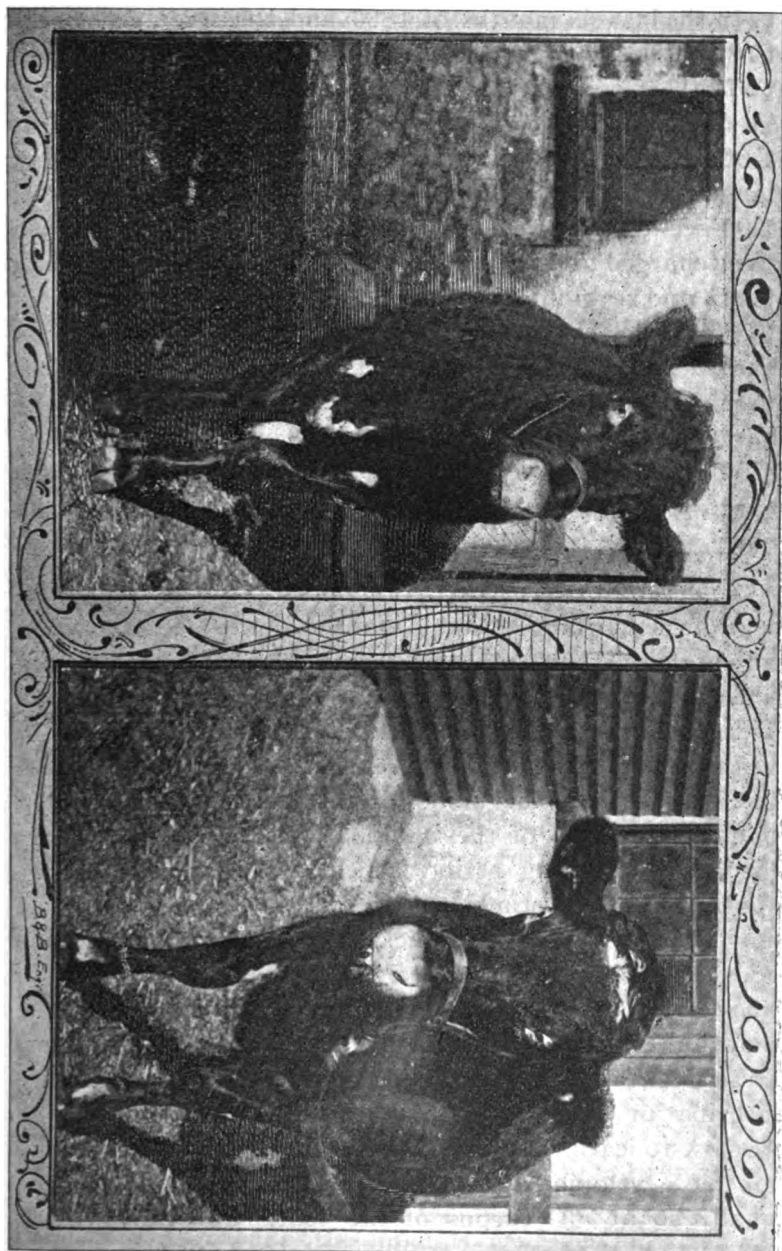
Fig. 2. Prince When Ready for the Block.

separated from the cream. The meal fed included wheat, bran, oats, barley, corn and oilcake. These foods were of course not all fed simultaneously, but in such combinations as were thought prudent from time to time. The grain was all ground. The hay was clover and timothy, chiefly the former, and was fairly good in character until the last winter, when it was chiefly timothy and of poor quality. The soiling food consisted mainly of green corn and green sorghum. The ensilage was corn. The pasture was blue grass, and was plentiful in supply. The field roots consisted mainly of mangels.

Food Values.—The food fed was charged at market values. These values represent the average price in the State that the farmer would obtain for such products when delivered at the ordinary place of sale, so far as those could be ascertained. The bran and oilcake were valued at the average cost to the farmer delivered on the farm, since these have usually to be purchased by the feeder. The prices for the foods fed are given below, and as they necessarily vary from year to year, the variations are also given. The following were the values for the last six months of 1895 and the first six months of 1896:

New milk per 100 pounds	\$0.63
Skim milk per 100 pounds	.12
Wheat bran per ton	6.50
Oats per bushel of 32 pounds	.14
Corn per bushel of 56 pounds.....	.18
Oilcake per ton.....	14.00
Clover hay per ton.....	3.50
Green food per ton	.75
Mangels per bushel of 50 pounds	.04½

During the last six months of 1896 and the first six months of 1897, the barley fed was charged at 16 cents per bushel of 48 pounds, and the corn ensilage at \$1.25 per ton. The prices for the other foods fed were the same as in the previous year.



Prince.

Fig. 8. Front View of the Steers Jack and Prince.

Jack

In the last six months of 1897 and the first six months of 1898, prices were materially advanced. Bran was charged at \$7.50 per ton, oats at 17 cents per bushel, barley at 20 cents, corn at 22 cents, oilcake at \$22.00 per ton, hay at \$4.00, corn ensilage at \$1.50, green food at 80 cents and mangels at 5 cents per bushel. The pasture was charged at \$1.00 per month, except while grain was being fed, when it was charged at 75 cents. The green food consisted mainly of corn and sorghum.

The prices charged for some of these foods were less than the amounts paid for them. For instance, the hay purchased cost probably \$2.00 per ton more than was charged for it. On the other hand, wheat bran bought at \$4.50 per ton, was charged at \$6.50. It was the aim to charge average market values throughout the State, as nearly as these could be ascertained, as already mentioned.

Character of the Growth Sought.—Up to the commencement of the finishing period it was the aim to keep the steers growing nicely without undue fatness. This was accomplished by feeding nitrogenous foods, and the preference was given to such of them as were cheap. The only period of even partial stagnation that occurred, was when the steers were on pasture. This unlooked for result is again referred to in that section of the bulletin which treats of pasture. During the finishing period which covered say the last 3½ months of the experiment, the process was reversed. The aim then was to fatten quickly by feeding carbonaceous foods, and as much as the steers could take with a relish. Quick and profitable fattening was made possible by the condition of good thrift in which the steers had been kept, a result that is practically unattainable when animals are unthrifty or lean when feeding for the block begins. Men are slow to learn that in growing meat, periods of stagnation in development are indeed expensive, though not equally so at all seasons of the year. Constant growth

upon suitable foods, has also a beneficial influence on the quality of the meat, as exemplified in this experiment.

Food Consumed.—Table I. gives the amounts of milk and of meal consumed by the steers respectively, until one year old.

TABLE I.

	New Milk.	Skim Milk.	Oilmeal.	Bran and Grain.
	Lbs.	Lbs.	Lbs.	Lbs.
Jack.....	172	3,383	56½	1,088
Prince.....	248	8,181	49½	998

They were fed new milk for 12 and 15 days respectively, and on an average of 12 pounds per day. One week or a little more than that was occupied in making the change from all new milk to all skim milk. Subsequent to this period skim milk was fed to Jack for 185 days, and at the average rate of 20 pounds per day. Skim milk was given to Prince for 166 days, and at the average rate of 18.7 pounds per day. The skim milk was thus fed for a period unnecessarily long, but it was given for the reason that it was plentiful at the station. Calves may be nicely reared on a quantity of skim milk considerably less than that fed per day in the experiment, and the milk may be withheld from them when necessary, ere they reach more than half the age of the calves under consideration, that is to say, it may be withheld at an age not much beyond three months. But when the milk is at all limited in quantity, care must be taken to give free access to ample supplies of good pure water.

The oilcake was fed in the form of meal. It was not given at all until the calves were about two months old, and yet they made good gains. It was given along with other meal, only a small quantity was fed at the first, not more than a teaspoonful a day, and during no part of the year was more than $\frac{1}{4}$ of a pound fed per day. The oilmeal was not fed while the animals were getting green food.

Ground flax would probably have given even better results during the continuance of the milk period, but oilcake was chosen because it can be more easily obtained by the farmers.

The feeding of meal, other than oilcake began simultaneously with the change from new milk to skim milk, and was continued through the remainder of the year. The meal consisted of bran and oats, and it was fed practically in the proportions of say 1 and 3 parts respectively. During the first part of the milk period they were virtually given all the meal they would eat with a relish, but none was allowed to remain uneaten. Subsequent to that period they would have eaten more, but in feeding the meal, the precaution was observed to give only enough to produce free and continuous growth, without inducing undue fatness. The average amount fed to Jack per day after the meal feeding began, was 3.14 pounds, and to Prince 2.78 pounds. The quantity fed never exceeded 4 pounds per day.

Table II. gives the quantities of food other than milk and meal consumed by the steers until one year old.

TABLE II.

	Hay.	Green Feed.	Corn Bullage.	Mangels.
	Lbs.	Lbs.	Lbs.	Lbs.
Jack.....	951	2452	232	1651
Prince.....	1106½	3418	337	780

It will be observed that Prince consumed more hay and other fodder than Jack, but that the latter consumed more mangels, and by consulting the above table, it will be seen that Jack consumed more meal than Prince. These differences arose in part at least from the individual preferences of the steers, to which a due regard was had throughout the whole duration of the experiment. But it was also caused to some extent, as in the case of feeding the mangels, by the season of the year at which the food was accessible. The feeding of the mangels commenced almost simultaneously with the

feeding of the grain, and continued while this food was in season. The mangels were fed sliced and in two feeds per day, and in no instance was more than 8 pounds fed per day.

The steers were not put out on pasture the first summer, and partly for the reason that none was conveniently accessible. But no special anxiety was felt with reference to such pasture, as it is yet an unsettled question as to whether calves for beef can be raised better and more cheaply on pasture, than on green food and adjuncts fed to them, where they can be kept reasonably cool and comfortable all the while.

Table III. gives the respective amounts of meal consumed by each steer between the ages of one and two years.

TABLE III.

	Oilcake.	Bran.	Oats.	Barley.	Corn.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jack	83	548	825	20	187
Prince .....	.....	482½	658	.....	184

It will be observed that the proportion of the oats to the bran fed was much less the second year than the first. It was thought that oats were less necessary than when the animals were younger, and bran was also the cheaper food. The average amount of the mixture fed to Jack per day during that part of the year that meal was being fed, was 5.19 pounds, and to Prince, 5.27 pounds, and at no time was either animal fed more than 7 pounds per day. The first was out on pasture for two months before he reached the age of two years, and the second was out on the same for four months. More or less meal was fed during the whole of the second year, except when the steers were out on pasture, as stated more minutely in a subsequent paragraph. No oilcake or barley was fed to Prince during the second year, and only a small quantity of either was given to Jack. This arose from the fact that he was nearly two months older than Prince. Though both were receiving the same

kinds of food, those charged against the two closing months of each year in the case of Prince, would be charged against the two first months in the following year in the case of Jack. This explanation also applies to the other apparent variations in food given, as, for instance, green food and pasture.

Table IV. gives the respective quantities of food other than meal consumed by the steers between the ages of one and two years.

TABLE IV.

	Hay.	Green Feed.	Corn Ensilage.	Mangels.
	Lbs.	Lbs.	Lbs.	Lbs.
Jack.	2,401	1,454	1,813	8,136
Prince.....	1,966	.....	1,219	8,291

It will be observed that during the second year Jack consumed considerably more of all kinds of food than Prince, except roots. Both were fed mangels from September 28th, 1896, to May 11th, 1897. The average amount given to Jack per day was 13.94 pounds, and to Prince, 14.62 pounds. At no time did the quantity fed to either exceed 20 pounds per day. The former consumed over 22 per cent. more of hay than the latter.

Table V. gives the respective amounts of meal consumed by the steers after reaching the age of two years.

TABLE V.

	Oilcake.	Bran.	Oats.	Barley.	Corn.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Jack.....	259½	399½	75½	404½	426½
Prince.....	229	342½	49	357	381

The finishing period began October 11th and ended January 31st, 1898, the last date at which the steers were weighed previous to being slaughtered. On September 7th when they were taken in from the pasture, each steer was being given 4 pounds of meal per day, and this amount was

gradually increased. On October 11th each was given 6 pounds of meal a day, consisting of bran, oats, corn and oilcake, fed in the proportions of 5, 2, 2 and 1 parts. On October 25th, the meal was changed to bran, barley, corn and oilcake, fed in the proportions of 3, 3, 3 and 1 parts respectively. And on November 15th the bran fed was reduced to 2 pounds, and the oilcake increased to 2 pounds instead of one. The quantity fed was increased gradually until December 28th when Jack was given 15 pounds of meal daily, and this amount was continued until the steers were sent to the block. On December 28th the grain portion given to Prince had been led up to 13 pounds per day. It had then to be reduced somewhat for a few days. It was again raised to 13 pounds, but could not always be maintained at that amount, and in no instance did it exceed 13 pounds. At no time of the finishing period could either steer be made to consume more than 15 pounds of meal per day, notwithstanding that a certain percentage of the same was bran, and that corn did not at any time form more than 33 per cent. of the whole meal portion fed.

Table VI. gives the amount of food other than meal that was consumed by the steers after they had reached the age of two years.

TABLE VI.

	Hay.	Corn Ensil'age.	Mangels.
	Lbs.	Lbs.	Lbs.
Jack.....	1068	1086	698
Prince.....	1003	1082	694

The corn ensilage, fed from November 1st onward, the date of opening the silo, averaged 12 pounds per day, and the mangels fed averaged 5.3 pounds per day for each animal. These were given more to keep the system in tone than for any other purpose. During the finishing period the meal was the main reliance for fattening in the absence of good hay.

Details of Feeding.—The hay was fed three times a day and only what they would eat clean. But if poor hay was fed they were not forced to eat it closely during the fattening period. The residue was removed and fed to other animals. The meal was fed in two feeds per day. While ensilage was being fed, the meal was given along with the ensilage, at other times it was fed directly. The mangels were sliced in the root cutter, and were fed twice a day except during the fattening period, when they were fed but once. The steers were kept loose in box stalls during the first year, but after that time they were tied when in the stables. Water was given to them twice a day. During the season of housing they were turned into a yard each fine day from a few minutes to several hours, and salt was kept in a trough in the yard where they could help themselves.

Cost of Food.—Table VII. gives the cost of the food fed during each period, and the increase in weight made by each animal.

TABLE VII.

	Cost of Food the First Year.	Increase in Weight.	Increase in Weight per Day.
Jack.....	\$15 28	Lbs. 670	Lbs. 1.84
Prince.....	14.81	693	1 90
	Cost of Food the Sec- ond Year.	Increase in Weight.	Increase in Weight per Day.
Jack.....	\$16.43	Lbs. 400	Lbs. 1.09
Prince.....	14.84	402	1.1
	Cost of Food the Third Period.	Increase in Weight.	Increase in Weight per Day.
Jack.....	\$13.51	Lbs. 365	Lbs. 2.03
Prince.....	10 56	228	1.81

It will be observed that the two steers made an average daily increase in weight of 1.87 pounds the first year. This increase includes the weight at birth. During the second year the average increase was only 1.09 pounds. This was certainly a poor showing. But in all experimental work common fairness demands that the bitter shall be given along with the sweet. It was caused by the miserable gains made while the steers were on pasture, to which further reference is made below. During the third period, Jack was fed for 180 days, and Prince for but 122 days.

Behavior While on Pasture.—The steers were out on pasture 127 days during 1897, that is to say, from May 24th until September 27th. When first turned on the pasture the aim was to give them grain for 14 days, by reducing the quantity gradually from 7 pounds until no grain would be given. But Prince would not eat any grain worth mentioning after he was turned out on grass. No grain was given again until September 6th, or 105 days from the date of turning onto the pasture. Grain was again given to both steers during the 21 closing days of the pasturing, but only in small quantities.

At the end of 105 days from the date of turning out on pasture, Jack had made an advance in weight of only 69 pounds, or .63 pounds per day. A small amount of grain was then given during the remainder of the pasturing period as previously stated, but which at no time exceeded 4 pounds daily and yet the daily increase in weight was more than 1½ pounds. The total increase in weight for the 127 days on pasture was 101 pounds, or .82 pounds per day. With Prince the results were still more unsatisfactory. During the first seven days on pasture, he decreased in weight from 1,018 pounds to 955 pounds, a loss of 63 pounds. During the next 7 days this loss was further increased to 73 pounds. At the end of 84 days from the date of turning out he was still 3 pounds lighter than when first put upon the pasture. After that time he began to gain slowly until grain was

again given on September 6th. He then gained 20 pounds in the remaining three weeks while on pasture, or .95 pounds per day. The entire increase while out on pasture was 97 pounds, or .63 pounds per day.

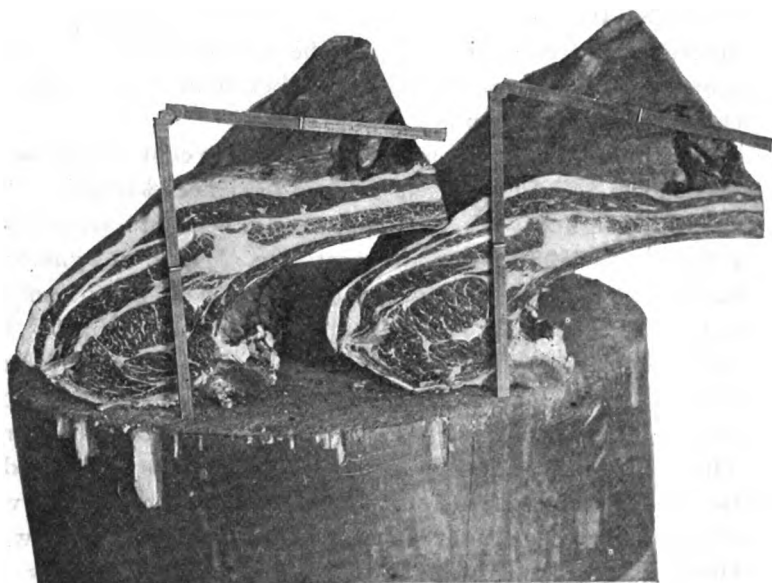
These results are not a little extraordinary. The pasture was plentiful and succulent. It was blue grass, which is considered one of the best for fattening. Such pasture is looked upon as being a perfect food. A gain of nearly 2 pounds per day was looked for, while the actual average daily gain was but little more than $\frac{3}{4}$ of a pound per day. The reasons are not quite clearly apparent. The true explanation, it may be, will be found in one or both of the following reasons: First, the grass was more than usually succulent, because of the excessive rainfall. The gains made by the sheep under experiment in an adjoining field were much less during the summer of 1897 than during that of 1896 or 1895, although the pasture was more abundant in 1897 than in either of the preceeding years. And second, it may be that when animals are fed a small grain portion daily and continuously for many months, a habit of digestion is engendered which calls for the continuance of such food.

Financial Summary.—The steers were sold to the supply department of the School of Agriculture: They were thus disposed of to enable Mr. Andrew Boss, the farm foreman, to secure data and illustrations regarding the relative outcome from the different cuts of the respective carcasses. The information thus obtained will be used by Mr. Boss in illustrative work in the butchering department. The steers were valued at the prices they would sell for in the live stock markets of St. Paul and Minneapolis. The values were fixed by two experts from South St. Paul. One of these, Mr. C. Engemoen, is live stock salesman for E. M. Prouty & Co., and the other, Mr. J. C. Crosby, is the live stock buyer for Swift & Co., at South St Paul. The price put upon Jack was \$4.75 per 100 pounds, live weight, and upon

Prince \$4.40. Both valuator's were of the opinion that the difference in price was placed at the extreme limit, and this opinion was well sustained by the behavior of the steers on the block as is shown below.

Including the value at birth, the entire cost of growing Jack was \$45.17, and of growing Prince \$40.21. The shrunk weights, with a shrinkage of 3 per cent. were 1,392 pounds and 1,280 pounds respectively. The first was sold for \$66.12, and the second for \$56.32. The profit on the first therefore was \$20.95 and on the second \$16.11. The items of interest on the money invested for food and in the plant are not taken into the account, nor was the cost of grinding the grain included. It was ground on the farm. The manure is supposed to offset the cost of labor and of bedding, and it should be borne in mind that the food was charged at average market values. The difference between these values and the cost of producing the food by the farmer should more than offset the interest on the money invested for food and plant while the steers were being reared.

Behavior on the Block.—In comparison with the shrunk live weight, the dead weight of Jack's carcass was 57.7 per cent. and that of Prince's 58.2 per cent. This was not in keeping with the general opinion expressed with reference to the steers before they were slaughtered, nor was it in keeping with what one would naturally expect from the conformation of the steers. But facts are facts, and cannot be gainsaid. To distort them with a view to make them fit preconceived theories in experimental work, is nothing short of a crime. The meat of both carcasses was simply superb in quality. Throughout the loin and rib cuts and also in other parts of the carcass, the admixture of the fat and lean, as brought out in the engraving, was simply perfect. Particles of fat of more or less size flecked the loin in all the best cuts, and in a way that the writer has never seen excelled. And this opinion was sustained by the juicy, tender



Jack.

Prince.

Fig. 4. Best Rib Roast.

and delicious character of the meat when served on the table. But little fat was laid on externally, and the per centage of internal fat was not high. The outcome in the carcasses was not far different. But all things considered, in Jack's carcass the covering of flesh on the bone was deeper than in the case of the other.

Observations—

1. It will be observed that no oilmeal was given to the calves until they were about two months old, that is to say, for about a month after the new milk ceased to be fed to them, and yet the daily gains made during the second month were 2.03 pounds on the average. This so far indicates that calves can be made to grow nicely on skim milk, bran and oats and good hay, without the aid of oilmeal at all, though they are likely to grow better when it is fed to them.

2. The greater capacity of Jack to stand forced feeding during the finishing period is worthy of notice. This capacity would seem to arise from greater inherent vigor of digestion, and was indicated in the outward form, more especially in the more compact build, the wider breast, and the better spring of rib. There was much more difficulty in getting Prince to take 13 pounds of meal per day than to get Jack to take 15 pounds, this was decidedly to the advantage of the latter, as shown in the greater gains which he made per day and also in the more complete ripeness of the carcass.

3. It is also worthy of notice that during the finishing period the steers, as already stated, could not consume more than 13 and 15 pounds respectively of meal per day. To this may be added some grain in the ensilage, but not a very large amount, probably not more than a pound a day. This would seem to confirm the view, that when cattle are fed from 25 to 30 pounds of grain per day during the finishing period, much of the grain so fed is wasted, even though pigs are made to glean amid the droppings.

4. The difference in the profit made by a small variation in the price paid, is well brought out in this experiment. Valuing the carcass of Jack at \$4.75 as was done, and that of Prince at \$4.40, the profit on the first exceeds that on the second by \$4.84. Had Prince also been valued at \$4.75 per 100 pounds, that excess of profit would have been reduced to 40 cents.

5. But for the low gains made by the steers when on pasture, the financial outcome would have been very much better. The entire gain of the two steers while out on pasture for 127 days was 198 pounds; a normal gain at such a time would have added fully 250 pounds more to the weight, which would have materially enhanced the profit from growing the steers. Hence the great loss from periods of stagnation in development when meat is being grown on the intensive plan when these occur.

6. Since the food fed was charged at the average market values in the state, the profit would have been considerably increased had it been charged at the cost of production. Such cost would be the correct basis of values could it be ascertained.

CONCLUSIONS.

1. Since the steers were sold for \$37.06 above the cost of production, under the conditions stated, it is just to conclude that a good profit can be made from growing beef in Minnesota, even when grown on the intensive plan.

2. That the method of growing meat thus is applicable to average farm conditions in the state, since the foods fed may all be produced on the farm, except the bran and oilcake.

3. That the quality of meat thus grown is of the very best, and should therefore command the highest price in the market.

4. That in growing beef as in this experiment, the farmer can get much better values for the food products which he grows by feeding them at home, rather than by selling them directly.

FATTENING RANGE STEERS IN WINTER.

SECTION NO. 2.

THOMAS SHAW.

It was intended that this experiment should be conducted on substantially the same lines as that of the previous winter which also experimented with feeding range steers, as detailed in Section 2 of Bulletin No. 58. But as will be shown in the proper place, it was found necessary to modify the whole plan of procedure, and for reasons that will be given. This experiment therefore is not a direct confirmation of that of 1896-97 as it was intended to be, in the sense of determining the relative results from feeding smaller and larger quantities of meal. It is confirmatory of the former however in so far as it throws light on the financial aspect of the question, and, notwithstanding the change of plan that was found necessary, the experiment presents some interesting and valuable features. But these will not be anticipated. In the proper place they will all be stated.

Time Covered by the Experiment.—The steers were put on full feed November 15th, 1897. They were sent to the block May 28th, 1898. The period of feeding therefore lasted for 194 days. On November 6th they were tied in the stall, and during the intervening days until the experiment proper began, they were gradually brought up to a full ration.

The Objects of the Experiment—As at first planned the chief of the objects sought in the experiment were the following: 1, to ascertain the comparative results from fattening steers on smaller and larger quantities of meal; 2, to gather information as to the behavior of range steers while under full feed, and 3, to learn the financial results. Chief among

the secondary objects were the following: 1, to learn the daily gains that would be made from a certain line of feeding; 2, to learn as to the consumption of food fed in producing these gains, and 3, to learn the cost of the same. One of the steers however had to be taken out of the experiment before it was fairly under way. He manifested a disposition so vicious and sullen that to continue him in the experiment did not promise any adequate results. He was exchanged therefore for another. A second steer manifested a shy and sullen disposition. When tied up he threw himself violently and for a good while loudly proclaimed his fancied wrongs by bellowing. As there was no other suitable steer on hand to supplant him, he was retained in the experiment until the end thereof. He continued shy and played the Ishmaelite in his disposition throughout the feeding period, and as a result made but poor gains. About the middle of the feeding period therefore the feeding of light, heavy and intermediate quantities of meal, as described below, was discontinued. The steers were all put upon what may be termed a pretty stiff grain portion, to ascertain if the daily gains would not be stimulated by such feeding. But as the results will show, the increased gains did not materialize. And just here it may be stated that the rebellious steers would probably have fattened fairly well in the open feed lot, though not so well as those of a better disposition. This remark is interjected here, lest the conclusion should be reached that range steers are not suitable material for being fattened. The behavior of these steers does not prove that. It simply proves that they are not the best of material for being fattened in the stall. While in our judgment they ought to be fattened loose and in a shed with access to a yard, such a method of fattening would not of course have given us the results that we sought.

The Animals Used.—Nine steers were fed in all. They formed part of a carload of cattle purchased by the Hon.

W. M. Liggett, the director, and the writer, on the range. The cattle were bought from John Manning, of Shelter Ranch, some 12 miles northward from Culbertson, in Montana, on the line of the Great Northern railroad. Seventeen animals were purchased. Some were young females that had failed to breed and some were native steers of fine finish. The cows and native steers were bought to be used, first, in demonstrative work in the slaughter house, and, second, on the dining tables of the School of Agriculture. They made a fine quality of meat. Four more animals owned by Mr. Manning completed the carload shipped to the Minnesota Transfer.

They reached the experiment farm October 20th, and were kept on blue grass pasture supplemented by some grain until November 6th, when the nine animals put in the experiment were weighed separately, and were tied in stalls side by side. The freight on the car from Culbertson to the Minnesota Transfer, 702 miles, including \$2.20 for food, was \$87.80. The proportion of the freight paid on the nine steers on the basis of weights was \$28.80, or \$3.20 on one steer.

In age the nine steers were two years old, but evidently there was no little variation in the age, as there was considerable variation in the size. In breeding, the shapes, the color markings, the presence or absence of horns, and the character of the horns when present, indicated Short-horn, Hereford and Aberdeen Poll blood. They had been sired by high grade or pure sires of one or the other of these breeds, and in individuality they were good, but a little more leggy than the really typical beef steer ought to be. Unevenness in size and dissimilarity in disposition were the chief points of weakness in the selection.

In determining the cost of the steers when the experiment proper began, November 15th, they were valued at the average price per pound paid for the whole lot when purchased on the range. No other course was open upon which

to base valuations, as they were not priced individually at the time of purchase. The proportionate cost of freight and food were added to this sum. They were also given the advantage accruing from the handling of the other animals in the carload lot. Taking these figures as the basis of the total outlay, the total cost of the nine steers up to November 15th was \$261.58, and the cost per 100 pounds, on the basis of weight when they entered the experiment, was \$2.69½ cents, a price considerably lower than the average market value of such animals at the time.

Conditions Governing the Experiment.—The steers were divided into three lots, with three in each. Those in lot 1 were to be fed the light meal portion, the steers in lot 3 the heavy meal portion, and those in lot 2 the intermediate quantity. As it was thought that weighing the steers so frequently the previous winter tended to disturb them unduly, it was determined that they should be weighed but once while the feeding was going on, in addition to the inevitable weighing at the beginning and at the close of the experiment. This intermediate weighing was made on March 7th, 112 days after the experiment began. They were of course not turned out to exercise. They were curried occasionally, at the first, with a brush on a handle and at a safe distance. Some of them, however, became quite tractable and responded nicely to kind treatment, while others continued to resent close handling until the end. And it is significant that the steers which responded best to handling made the best gains.

Food and Feeding.—The meal fed to the steers for the first 112 days of the experiment was composed of bran, barley and corn. The first period of 28 days it was fed in the proportions of bran 5 parts, barley 3 and corn 2. The second period of similar duration it was changed to bran 4 parts, barley 3 and corn 3. The third period it was made up of 3 parts bran, 3 barley and 4 corn. And in the fourth period it was further changed to 2 parts bran, 3 parts barley and

5 parts corn. These proportions are by weight. The aim in thus changing the food frequently was to increase gradually the more carbonaceous and more concentrated factor of the food, viz. the corn. At the commencement of the experiment, the steers in lot 1 were fed 6 pounds per day of the mixture, the steers in lot 2, 8 pounds, and the steers in lot 3, 10 pounds. These respective amounts were increased 1 pound at the end of every four weeks, and during the first 112 days of the experiment 1 pound of oilcake in the nutted form was given to each steer per day. When the steers were weighed on March 7th, it was apparent from the behavior of the steer No. 4 that the experiment was so marred, that in one of its essential objects, viz. comparison of the results from the light and heavy grain feeding, it would be only prudent to abandon it. It was determined at the same time to try and ascertain if heavy feeding during the remainder of the term would stimulate greater gains. The meal portion was changed to bran and corn in the proportions of 1 and 3 parts, and it was decided to feed all the steers up to their capacity for consumption without putting them off their feed. The 1 pound of oilcake per animal was also continued and during the last 25 days of the experiment it was changed to 2 pounds.

Mixed hay, timothy and clover, of medium quality, was fed in quantities such as the steers would consume. And after 112 days of feeding, corn ensilage was added. Of this however they only consumed from 6 to 8 pounds per day, and one steer, viz. No. 6, would not take any. The grain was ground and fed directly, in two feeds per day. The hay was given in the uncut form and in three feeds per day. And the ensilage was fed in two feeds.

Estimated Value of the Food.—The food was estimated at what may be termed approximate average market values for the state. They were as follows:

Bran, per ton.....	\$7.50
Barley, per bushel of 48 pounds.....	.18

Corn, per bushel of 56 pounds.....	.22
Oilcake, per ton.....	22.00
Hay, mixed, per ton.....	4.00
Corn ensilage.....	1.25

Five cents per sack is the common charge for grinding coarse grain. Adding the cost of grinding to the barley and corn, makes the cost of these 20½ cents and 24½ cents respectively per bushel.

These prices were considerably in advance of those allowed for nearly all the products during the three previous years. The most notable advance, however, is oilcake, which went up in a single season from \$14.00 to \$22.00 per ton. The advance in these values of course add to the cost of the feeding and in the absence of higher prices for the finished product, correspondingly reduces the profit that would otherwise have accrued.

Food Consumed.—Table VIII. gives the total amount of hay, ensilage and meal consumed by each steer during the experiment and the sum of these taken together.

TABLE VIII.—Food Consumed by the Steers.

	Hay	Ensilage.	Meal.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.
No. 1.....	1,985	633	2,132	4,730
No. 2.....	1,552	637	2,356	4,545
No. 3.....	1,847	639	2,615	5,101
No. 4.....	1,380	640	2,100	4,120
No. 5.....	1,656	598	2,331	4,585
No. 6.....	1,621	594	2,665	4,886
No. 7.....	1,871	594	2,123	4,588
No. 8.....	1,912	641	2,371	4,924
No. 9.....	1,609	635	2,588	4,832
Total.....	15,413	5,017	21,281	41,711

The variable quantities of food consumed are not to be attributed entirely to variations in the capacity of the steers to consume, as, during the first 112 days of the experiment, they were fed varying quantities of meal.

Table IX. gives the quantity of each food factor consumed daily by each individual steer throughout the experiment, and also the total daily consumption of food by each.

TABLE IX.—Daily Consumption of Food by the Steers.

	Hay.	Ensilage.	Meal.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.
No. 1.....	10.18	3.26	10.99	24.38
No. 2.....	8.00	3.28	12.14	23.42
No. 3.....	9.52	3.29	13.48	26.29
No. 4.....	7.11	3.30	10.82	21.23
No. 5.....	8.54	3.08	12.02	23.64
No. 6.....	8.35	.....	13.74	22.09
No. 7.....	9.64	3.06	10.94	23.64
No. 8.....	9.86	3.30	12.22	25.38
No. 9.....	8.29	3.27	13.84	24.90
Average.....	8.83	2.87	12.19	23.89

In the above table we are given an approximate idea of the daily consumption of food by steers weighing as these did in the experiment, when fed practically on a dry ration. The average weight of the nine steers during this period of feeding was 1178 pounds. The consumption of meal was a little more than 12 pounds per day. It is certainly under 13 pounds allowing for what might be in the ensilage. This amount is far short of what is fed on an average in the feed lots of the west. During the first 112 days of the experiment some of the steers would have consumed more grain if it had been given to them, but it is more than questionable if increased gains would have resulted, as will be shown later. The difference in the amounts of food consumed per day is relatively much less than the difference in the proportionate gains resulting from them.

Weights of the Animals.—Table X. gives the weights of the individual animals at the commencement of the experiment and at its close and also the total individual increase and the average daily individual increase made during the same.

TABLE X.—Weights and Increase.

	Weight on Nov. 16, 1897.	Weight on May 28, 1898.	Total Individ- ual Increase.	Daily Increase.
	Lbs.	Lbs.	Lbs.	Lbs.
No. 1.....	1100	1445	345	1.78
No. 2.....	840	1155	315	1.64
No. 3.....	1075	1520	445	2.29
No. 4.....	950	1105	155	.80
No. 5.....	1065	1275	210	1.08
No. 6.....	1075	1315	240	1.24
No. 7.....	960	1220	260	1.34
No. 8.....	1125	1440	315	1.62
No. 9.....	1150	1380	230	1.19
Average.....	1038	1317	279	1.44

There are some things in the above table that are calculated to somewhat perplex any one who has made a study of the feeding question. First, there is the uncommon disparity in the gains made by individual steers. Leaving out No. 4 for the present, it will be noticed that three steers, Nos. 1, 3 and 8, made together a daily increase of 5.69 pounds, while the three steers Nos. 5, 6 and 9 made together a daily increase of but 3.51 pounds. The first three consumed together 36.69 pounds of meal daily, and the last three 39.10 pounds. The first three weighed together 3,300 pounds when the experiment began, and the last three weighed together 3,290 pounds at the same date.

Second, the difference in type in the steers does not sufficiently account for the disparity in the individual gains. Of the six steers mentioned above, No. 9 only was pronouncedly off in type. No. 3 made an increase of 2.29 pounds per day, an uncommon increase for so long a period of feeding. No. 9 which consumed practically the same amount of meal gained only 1.44 pounds per day. This however was looked for from the pronounced difference in the type of the steers. No. 5, taking 12.02 pounds of meal per day on an average, made a daily gain of but 1.08 pounds as compared with 2.29 pounds, less than half as much as was produced by the steer No. 3, which took but 13.48 pounds of meal per day. Here the types were not far different. Some judges preferred the form of No. 5 when the

feeding began. He took his feed regularly, but who can tell what he did with it? It was apparently digested so far as one could judge by the droppings. No. 4, the nervous and ill-natured steer only gained .80 pounds per day. The reason in this case is clear. He would not eat enough, nor would he rest. But why did No. 6 gain only 1.24 pounds per day, though he consumed more meal than No. 3. The type in the case of No. 6 was not much inferior if any to that of No. 3.

From such behavior we are driven to the conclusion as one result of this experiment, that we must not rely too much upon type. While we can make a grand good use of it in selecting animals for feeding as in selecting them for the dairy, we must not stake everything on it. In both there are some exceptions. The inheritance of certain other things would seem to be quite as important as the inheritance of form. In some instances at least some subtle influences lie away down in the digestive system of an animal which baffle preconceived judgments as to the outcome. Did we know more about the inheritance of the animals we would doubtless be less at sea. In the meantime we do wisely when we remember that in selecting animals, form does not tell all the story of their fitness for a certain end.

Third, the absolute average gains made were low, notwithstanding that they were excellent in at least three instances. With the steer No. 3 they were superior to any gains that have yet been realized at this station for so long a period of feeding. Had the gains made by all the steers been low, we would have sought for the result in some untoward conditions regarding food or management, or both, but the marked well-doing of some of the steers sets this at rest. That the steers made an average gain of but 1.44 pounds per day must, therefore, be owing to the poor feeding quality in some of the steers.

And just here it may be mentioned that increasing materially the proportions of concentrated foods fed did not

mend matters. During the first 112 days of the experiment, the steers made an average daily gain of 1.50 pounds. To produce this gain they were fed daily on an average, 10.26 pounds of hay and 10.49 pounds of meal. Subsequently they made a daily gain of but 1.36 pounds, though given each day 6.06 pounds of hay, 6.79 pounds ensilage, and 14.51 pounds of meal. In fact, during those 82 days they were given all the meal that they could stand. Of course, during the last part of a term of feeding, animals require more food to make equal gains, but had it been a fact that some of the steers were being fed too little meal before March 7th they should have gained more rapidly subsequently, which they did not. To illustrate, take the three steers that were fed a light meal portion up to March 7th, viz., Nos. 1, 4 and 7. Previous to that date they were fed daily on an average 8.48 pounds of meal, and gained 1.31 pounds each per day. Subsequently they were fed on an average 14.25 pounds of meal each per day, and made an average daily gain of 1.30 pounds.

Table XI. gives the cost of each food factor fed to the individual animals, and also the cost of these taken together.

TABLE XI.—Cost of Food Consumed.

	Hay.	Ensilage.	Grain.	Total for Each Steer.
No. 1.....	\$3.93	\$0.79	\$10.42	\$15.14
No. 2.....	3.10	.80	11.34	15.24
No. 3.....	3.69	.80	12.43	16.92
No. 4.....	2.75	.80	10.28	13.83
No. 5.....	3.31	.75	10.23	14.29
No. 6.....	3.24	.....	12.65	15.89
No. 7.....	3.74	.74	10.38	14.86
No. 8.....	3.88	.80	11.41	16.09
No. 9.....	3.22	.79	12.31	16.32
Total.....	\$30.86	\$6.27	\$101.45	\$138.58

A noticeable feature of this and indeed of all feeding for the block is the marked contrast between the cost of the fodder and that of the grain. The former cost \$37.13 and

the latter 101.45, or nearly three times as much, hence the wisdom of trying to utilize fodder as far as may be consistent when fattening animals.

Table XII. gives the average daily cost of the food consumed by the individual animals during the first 112 days of the experiment, during the last 82 days of the same, and during the whole experiment.

TABLE XII.—Average Daily Cost of Food Consumed.

	For the First 112 Days.	For the 82 Last Days.	For the Whole Ex- periment.
	Cts.	Cts.	Cts.
No. 1.....	6.50	9.46	7.80
No. 2.....	6.96	9.07	7.86
No. 3.....	8.09	9.69	8.72
No. 4.....	5.79	8.96	7.18
No. 5.....	6.17	8.99	7.37
No. 6.....	7.58	9.02	8.19
No. 7.....	6.54	9.18	7.66
No. 8.....	7.87	9.49	8.27
No. 9.....	7.77	9.29	8.42
Average.....	6.97	9.23	7.94

The average daily cost of the food consumed rises from 6.97 cents per animal per day, during the first period of 112 days of moderate feeding, to 9.23 cents per day during the second period of 82 days of forced feeding. That the daily cost usually rises with the advancement of the fattening period, and that the daily gains usually decrease somewhat, is common experience. But in this experiment the relative rise is more than it would have been under a more moderate system of feeding. The ration fed was, therefore, unnecessarily costly, while the forced feeding was in process, and the gains resulting were probably less than they would have been under more moderate feeding.

Cost of Increase.—Table XIII. gives the cost of making 100 pounds of increase by each animal during the first 112 days of the experiment, during the last 82 days of the same, and during the entire experiment.

TABLE XIII.—Cost of Increase per 100 Pounds.

	For the first 112 days.	For the last 82 days.	For the whole period, 194 days.
No. 1.....	\$4.03	\$4.79	\$4.89
No. 2.....	3.90	6.47	4.84
No. 3.....	3.29	4.62	3.80
No. 4.....	8.31	9.54	8.92
No. 5.....	5.20	9.57	6.80
No. 6.....	5.74	8.04	6.62
No. 7.....	4.12	9.18	5.71
No. 8.....	4.13	6.77	5.11
No. 9.....	7.25	6.98	7.10
Average.....	\$5.11	\$7.82	\$5.92

The wonderful difference of individuality in animals that are being fattened, in turning the food fed to them to account, is well brought out in the above table. While the steer No. 3 made 100 pounds of increase at a cost of \$3.80, the steer No. 4 made the same at a cost of \$8.92.

Profit Made.—Table XIV. gives, 1, the value of each individual steer when the experiment began; 2, the cost of the food fed; 3, the total outlay; 4, the value of each animal when the experiment closed; and 5, the profit made on each. The totals are also given in each instance.

TABLE XIV.—Values and Profit Made During the Experiment.

	Value on Nov. 15, when the experiment began.	Cost of Food.	Total Cost.	Value on May 28, '98, when the experi- ment closed.	Profit.
No. 1.....	\$29.65	\$15.14	\$44.79	\$66.83	\$22.04
No. 2.....	22.64	15.24	37.88	53.42	15.54
No. 3.....	28.97	16.92	45.89	70.30	24.41
No. 4.....	25.60	13.83	39.43	51.11	11.68
No. 5.....	28.70	14.29	42.99	58.97	15.98
No. 6.....	28.97	15.89	44.86	60.82	15.96
No. 7.....	25.87	14.86	40.73	56.43	15.70
No. 8.....	30.32	16.09	46.41	66.60	20.19
No. 9.....	30.99	16.32	47.31	63.83	16.52
	\$251.71	\$138.58	\$390.29	\$548.31	\$158.02

The results as stated above do not take any account of shrinkage and for manifest reasons. This is done when the financial statement is given.

The profit is most satisfactory, but it does not arise from good gains, for, as previously shown, these were on the average low rather than high. The substantial profit is then the outcome of the low cost price of the steers as compared with the selling price, than of successful feeding.

While the profit made from feeding 9 steers for 150 days in 1896, that is to say, during the experiment proper, was only \$43.17, as stated in Bulletin No. 58, Section No. 1, the profit from the nine steers now under consideration was \$158.07, during the 194 days of the experiment proper, and yet the gains made during the former were much better than during the latter. The great influence which the price paid and received exercises on profit is thus emphasized.

The difference in the individuality of animals is well brought out in the results of this experiment. If the steer No. 3, which made the highest profit, is contrasted with the steer No. 4, which made the lowest profit, the comparison stands thus: While the former gave a profit of \$24.41, the latter gave a profit of but \$11.68, that is to say, not half as much. And if the three steers which made the highest gain are contrasted with the three which made the lowest gain, the comparison stands thus: While the profit on the first three aggregated \$66.64, the profit on the last three aggregated but \$12.92. Great is the power of individuality even in steers that are being fattened.

It may also be mentioned here that the increase made during the experiment cost \$5.92 per 100 pounds. As it was sold for \$4.62½ per 100 pounds, it cost more than it was worth, a result brought about, first, by the advanced cost of food, and, second, by the moderate gains resulting from feeding it. In two instances only was the increase made worth more than the food used in making it. These were with the steers in Nos. 1 and 3 respectively.

Disposal of the Steers.—The steers were sold to Peter Van Hoven, of New Brighton. They were slaughtered for home consumption, that is to say, consumption in the twin

cities of St. Paul and Minneapolis. The price paid, as stated above, was \$4.62½ per 100 pounds with a shrink of 3 per cent.

<i>Financial Statement.</i> —Cash received for 9 steers May 28th, 1898, shrunk weight 11,499 pounds, at \$4.62½ per 100 pounds.....		\$531.83
Value of 9 steers on November 15th, 1897, on the basis of cost.....		\$251.71
Cost of food.....		138.58
Total outlay.....		\$390.29
Total net profit.....		\$141.54
Net profit on one steer.....		15.73

Observations.—1. Since the food fed was charged at the average market values in the state, these would represent more than the cost of growing the same, and would therefore be so far unfavorable to the making of profits.

2. The value of the manure is supposed to offset the cost of bedding and labor, and also the interest on the money involved.

3. Had the experiment been closed on March 7th, and had the steers been then valued, as they might justly have been, at the prices for which they were sold, viz., \$4.62½ per 100 pounds, the greatest profit would have been realized from the three steers in lot 1, which were fed the light meal portion. The respective profits, excluding shrink, would have been for those of lot 1, \$57.21; for those in lot 2, \$54.58; and for those in lot 3, \$55.59.

IMPORTANT FACTS SUMMARIZED.

Values—

1. Value per 100 pounds on the basis of cost when the experiment began, Nov. 15th, 1897.....\$2.69½

2. Value per 100 pounds on the basis of actual receipts, May 28th, 1898, when the experiment closed.....\$4.62½
3. Advance in value per 100 pounds..... 1.93

Freight—

1. Cost of freight on a carload of cattle (21 animals) from Culbertson, Montana, to St. Paul, 702 miles, including food charges (\$2.20)..... 87.80
2. Average cost of freight per animal on the 9 steers fed in the experiment on the basis of weights..... 3.20

Weights—

- | | Lbs. |
|---|-------|
| 1. Average weight of the steers when the experiment began, Nov. 15th, 1897..... | 1,038 |
| 2. Average weight at the close of the experiment, May 28th, 1898..... | 1,317 |

Increase in Weight—

- | | |
|---|------|
| 1. Average increase in weight of each steer during the 194 days of feeding..... | 279 |
| 2. Average increase in weight per day of each steer during the first 112 days, when the feeding was moderate..... | 1.50 |
| 3. Average increase in weight per day of each steer during the last 82 days, when the feeding was forced..... | 1.36 |
| 4. Average increase in weight per day of each steer during the 194 days of feeding..... | 1.44 |

Food Consumed—

1. Average daily consumption of meal per animal during the first 112 days, when the feeding was moderate..... 10.26
2. Average daily consumption of meal per animal during the last 82 days, when the feeding was forced..... 14.51

3. Average daily consumption of meal per animal during the entire period of feeding.....	Lbs. 12.19
4. Average daily consumption of food per animal during the whole period of feeding.....	23.89

Cost of Food.—

	Cts.
1. Average cost of food per animal per day during the first 112 days when the feeding was moderate	6.97
2. Average cost of food per animal per day during the last 82 days, when the feeding was forced.....	9.23
3. Average cost of food per animal per day during the whole period of feeding.....	7.94

Cost of Increase.—

1. Average cost of making 100 pounds of increase during the first 112 days of the experiment when the feeding was moderate.....	\$5.11
2. Average cost of making 100 pounds of increase during the last 82 days when the feeding was forced	7.32
3. Average cost of making 100 pounds of increase during the whole period of feeding.....	5.92

Increase in Value.—

1. Average value of each steer without shrink on the basis of cost when the experiment began, November 15th, 1897.....	27.97
2. Average value of each steer without shrink when the experiment closed, May 28th, 1898	60.91
3. Average advance in value on each steer from feeding for 194 days, or, during the entire experiment.....	32.94

Profits.—

1. Aggregate net profit from feeding 9 steers for 194 days	141.54
2. Average net profit from feeding one steer for the same period.....	15.73

CONCLUSIONS.

The following are prominent among the conclusions that may legitimately be drawn from the experiment:

1. That inasmuch as the steers fed on the light meal portion gave the largest profit until March 7th or as long as they were thus fed, this result is in keeping with those previously obtained from feeding steers thus at our station.

2. That because of the sullen temper and restless bearing of two of the steers when first tied up and of the ill-doing of the one of these retained in the experiment, range steers would not seem to furnish very suitable material for being finished in the stall.

3. That the difference in the capacity of animals to make increase is very great, since in this experiment, the average daily gains on the same ration in kind ranged from .80 pounds per day to 2.21 pounds per day.

4. That the great difference in the ability of animals to give profitable returns while being fattened is emphasized in the fact that the steer No. 3 made 100 pounds of increase at an average cost of \$3.80, while with the steer No. 4 it cost \$8.92 to secure a similar increase.

5. That while good type is one guaranty of good feeding, it alone does not furnish a sure guaranty, as witnessed in the low profits relatively from the steers Nos. 4, 5 and 6, all of which were possessed of good type.

6. That the decrease in the relative gains during the last 82 days of the experiment, with the marked increase in the cost of the same while the steers were under what may be termed a forcing ration, emphasizes the futility of attempting to force gains by excessive grain feeding.

Some Averages from Two Experiments.

The following are some of the more important of the averages obtained from feeding range steers taken from the two experiments conducted at our station in this line of work.

Values—

1. Value per 100 pounds on the basis of cost when the animals were first put under experiment.....\$2.91½
2. Value per 100 pounds on the basis of receipts when the animals were sold..... 4.62½
3. Advance in value per 100 pounds..... 1.71½

Weights—

- | | |
|---|---------------|
| 1. Average weight per animal when put under experiment..... | Lbs.
1102½ |
| 2. Average weight per animal, without shrink, at the close of the feeding period..... | 1367 |
| 3. Average increase in weight per animal per day.... | 1.67½ |

Food Consumed.—

1. Average amount of meal consumed daily by one animal..... 11.65
2. Average amount of ensilage consumed daily by one animal..... 10.76
3. Average amount of hay consumed daily by one animal..... 9.19
4. Average amount of food consumed daily by one animal..... 31.60

Cost of Food Consumed,—

- | | |
|---|--------------|
| 1. Average cost of food for one steer per day..... | Cts.
7.57 |
| 2. Average cost of making 100 pounds of increase... | \$4.94 |

Increase in Values.—

1. Average value when the experiment began, without shrink..... 32.24
2. Average value when the experiment closed, on the same basis..... 63.22
3. Average advance in value from feeding for an average period of 162½ days..... 30.98

Profit.—

1. Total net profit on 18 steers in the two experiments 294.29
2. Average net profit on one steer..... 16.35

FEEDING PIGS OF DIFFERENT GRADES.

SECTION NO. 3.

THOMAS SHAW.

No question pertaining to the growing of live stock is attracting so much attention to-day in the United States as that of the bacon hog. Nor is there any question in live stock circles that is provoking so much of controversy. The writer has had but one opinion on this question, viz.: That the average hog grown in the United States must be so modified in the near future as to more nearly resemble the bacon hog in form and characteristics, and that the change will have to be made, even though not one pound of bacon should be sent to the markets of Great Britain. This change would seem to be inevitable for the reason, first, that the taste of the consumer calls for leaner pork than was in demand during the recent vanishing days when the lard era prevailed; second, that it will give our pigs more bone and stamina, the latter of which is the crowning requisite of domestic animals; third, that it will greatly increase the prolificacy of our swine, and, fourth, it will accomplish all this without seriously decreasing their capacity to produce much increase relatively from a minimum of food.

There are two ways of obtaining such a result. The first is by selection, and the second is by crossing. The first is the easiest of adoption by far by the average American breeder, because of the paucity of the material for crossing, but it is considerably the slower method of the two. By the first method the swine grower must needs select sows for breeding long and deep and rangy in body, and standing on good limbs. He must needs select good, strong, vigorous boars, but less rangy than the sows. He must adapt his food to the needs of the bacon hog by making it more

nitrogenous than a diet is when composed mainly of corn, and in a few generations he will have his bacon hog, and without any serious diminution of good growing and good feeding qualities. By the second method, boars of the Improved Large Yorkshire and Tamworth breeds will be crossed upon the short-bodied sows that abound in all parts of the land, and more especially within the corn belt. The boars of these respective breeds should only be chosen for these crosses with discrimination. Those rangy beyond a certain degree should be rejected, lest excessive range in the male should impart to the progeny a lack of feeding qualities. The first cross will give the animal sought. If our people would only smash and throw away the glasses of prejudice with which they view this matter, and if they would but introduce this cross where it can be done, they would be astonished at the renovating influence it would have upon their swine in a single generation.

With the writer, experimentation with these crosses is no new thing, nor is experience in growing the Improved Yorkshire and Tamworth swine. While at the Ontario Experiment Station, these crosses were being made from year to year. Not much was published, however, regarding them, because of the severance of relations with that institution at a time when the work was yet in progress. But enough was done to convince one of the much power which both these breeds have to bring great renovation to the swine that we have, enfeebled, as many of them are, by generations of imprudent feeding, more especially in the corn belt.

Experimentation in making these crosses began at our station in 1894. This was some three years prior to the now famous utterance of Secretary Wilson on Tamworth swine. And much material would now be on hand for publication with regard to them, but for an untoward event that destroyed so much of the same as to well nigh erase the somewhat elaborate system of crosses that had been

instituted. In an evil hour the pestilence that walketh in darkness swept through our herd and it left us with much of our precious treasure to bury in the form of dead swine. The dread disease hog cholera had been brought to us in the early spring of 1897, doubtless by some visitor, and we were left lamenting the loss of the work of years.

Our little experiment however escaped the wreck, and for the reason that it had been completed the previous autumn, the details of this experiment are given in the bulletin. When speaking to the farmers about these crosses, the writer had been frequently met with the objection, that while the first cross might be good, the second cross would show retrogression, and that subsequent crosses would show still further retrogression. The experiment was undertaken in the hope of throwing some light on the question raised, and more especially as to the relative merits of the progeny of Improved Yorkshire sires of the first and second crosses. The direct bearing of this whole question upon the future prosperity of our State is the apology for the somewhat prolonged introduction to this bulletin, since no State in the Union possesses a higher natural adaption to the production of the bacon pig than our own, because of the great variety and abundance of the foods that may be grown.

Time Covered by the Experiment.—The experiment commenced July 13th, 1896. It ended November 2d of the same year. It thus covered 112 days. It was made up of four periods of 28 days each. It is not to be regarded simply as an experiment in fattening swine, but rather as an experiment in growing and fattening them combined.

The Objects of the Experiment.—Chief among the objects of the experiment were the following: 1, to ascertain the relative merits of swine of the first and second crosses from improved Yorkshire sires in producing growth and for fattening; 2, to ascertain the relative values of corn and barley respectively as food for swine when fed as in the experiment; and 3, to ascertain the financial outcome under

the existing conditions. And prominent among the secondary objects were the following: 1, to ascertain the relative daily increase; 2 the food used in making it; and 3, the cost of the same.

The Animals Used.—The animals used in the experiment were chosen from two litters, designated respectively as the first and second Yorkshire crosses. Six individuals of each cross were fed. Those of the first cross were from a first class pure bred improved Yorkshire boar and a high grade Berkshire sow of somewhat heavy build. In the sow there was probably a dash of Poland China blood as indicated by her large and almost pendent ears. The pigs of the second cross were by the same Yorkshire sire and out of a first cross Yorkshire dam. This dam was the progeny of the sow referred to above and a pure Yorkshire sire. The grade Berkshire dam was of course black in color with white points. The first cross Yorkshire dam was pure white, a beautifully formed and handsomely developed sow.

The six first cross pigs were from the second litter produced by the dam. The litter comprised 8 living animals. They were farrowed March 27th, and were reared on the dam until fully 10 weeks old. Subsequently and until they entered the experiment, they were fed skim milk and shorts with a small proportion of oats and barley added. They had the run of a pasture of about an acre, more or less, but could get but little food therefrom, and in consequence they were given some green food, chiefly grass, which was carried to them. The six second cross pigs were the first litter produced by the dam, and they embraced the whole litter. They were farrowed March 30th, and were similar in all respects to the pigs of the first litter.

Conditions Governing the Experiment.—The pigs were divided into four lots of 3 each. Lots 1 and 3 comprised pigs of the first cross and lots 2 and 4 pigs of the second cross. Lots 1 and 2 were given the corn diet described below, with adjuncts, and lots 3 and 4 were given the

barley diet with similar adjuncts. The apartments of the piggery in which they were fed were side by side, and each was 8x12 feet in area. Each lot had the run of a small paddock for an hour or more every day. The pigs were weighed at the beginning and close of the experiment, and also at the end of each intervening week.

Both litters were 108 days old when the experiment began; as the pigs of the first cross were put under experiment 3 days earlier than those of the second cross, but with them the experiment also ended 3 days sooner. The conditions of the experiment therefore were very even. The pigs were from the same sire, were farrowed practically at the same time, and were the same age when the experiment began and closed.

Food and Feeding.—The pigs in lots 1 and 2 were fed oats and corn during the first period in the proportions of 3 and 1 parts respectively by weight. During the second period the proportions of these foods were 2 and 2 parts respectively. During the third period they were 1 and 3 parts respectively, and during the fourth period corn only was fed. The pigs in lots 3 and 4 were fed similarly except that barley was substituted for corn. The grain was all ground. It was prepared by soaking in cold water for 12 hours previous to feeding, but that fed at noon was soaked for but six hours. A small amount of salt was also added daily to the food. It was fed in three feeds, and the pigs were given all that they would eat clean and with a relish. They were also given such green food as was in season. The green food comprised corn, second growth clover, rape and cabbage.

Estimated Value of the Food.—The food was estimated at the average market values in the State. These were very low at the time, but not relatively lower probably, than the price of pork.

These market values were as follows:

Oats, per bushel of 32 pounds.....	\$0.14
Barley, per bushel of 48 pounds.....	.16

Corn, per bushel of 56 pounds..... \$0.18

Green food, per ton..... .75

An allowance of 5 cents per sack was made for grinding the grain. This is the usual charge for such work. The charges for grinding, therefore, would make the oats 16½ cents, the barley 18½ cents and the corn 20½ cents per bushel.

Food Consumed.—Table XV. gives the respective amounts of each kind of grain and also of the green food consumed by the animals of the respective lots; first, during each period of the experiment, and second, during the whole experiment.

TABLE XV.—Food Consumed by the Pigs.

	Oats.	Corn.	Green Food.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.
Lot 1—				
First Period.....	17½	62½	106	346
Second Period.....	136	136	60	332
Third Period.....	100½	301½	90	492
Fourth Period.....		480	66	546
Total.....	414	980	322	1,716
Lot 2—				
First Period.....	197	65	130	392
Second Period.....	142	142	52	336
Third Period.....	110½	331½	30	472
Fourth Period.....		495	85	580
Total.....	449½	1,033½	297	1,780
Lot 3—		Barley.		
First Period.....	151	54	111	316
Second Period.....	132	132	60	324
Third Period.....	87	261	30	378
Fourth Period.....		361	66	427
Total.....	370	808	267	1,445
Lot 4—				
First Period.....	185	59	130	374
Second Period.....	134	134	52	320
Third Period.....	139	255	30	424
Fourth Period.....		378	85	463
Total.....	458	826	297	1,581

It will be observed that the total consumption of food was greatest with the pigs which were given corn rather

than barley. While this was true from the commencement of the feeding period, it was more remarkably so during the later periods of the feeding. This would seem to bear out the idea which to some extent prevails, that barley tends to decrease the appetite, when fed freely to swine for a long period. The difference in the amounts of green food consumed during the different periods is also very noticeable. This was owing largely to the kind of the food fed, and to the succulence of the same. At the first, succulent corn was fed. Of this the consumption was considerable. Then the corn became less succulent, and there was a decrease in the consumption. Toward the last, rape and cabbage were fed. Pigs are fond of both, and both are excellent adjuncts to a heavy grain diet. But the relatively small consumption of green food to the total consumption is also noticeable. The total of grain consumed was 5,339 pounds, and the total of green food 1,183 pounds, that is to say, the consumption of the latter was only a little more than 22 per cent. of the former.

Table XVI. gives the average amount of each food factor consumed per day by the animals in each lot, and the total average daily consumption of these taken singly and together.

TABLE XVI.—Daily Consumption of Food.

	Oats.	Corn.	Barley.	Green Food.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Lot 1.....	1.23	2.92	.....	.96	5.11
Lot 2.....	1.34	3.08	.....	.88	5.30
Lot 3.....	1.10	.....	2.40	.79	4.29
Lot 4.....	1.36	.....	2.46	.88	4.70
Average.	1.26	3.00	2.43	.88	4.83

Reference has already been made to the greater consumption of food by the lots which received the corn as compared with those which received the barley. In this table the contrast is rendered more apparent. The difference in the average consumption of corn per day as com-

pared with barley was a little more than half a pound. But the whole of this is not to be attributed to the diet, as the pigs in lot 3 were low in consumption of food relatively, to some extent at least, from constitutional bias. They were lowest, as will be seen later, in point of gain. The pigs of the first cross consumed somewhat less food per day than those of the second cross. The average daily consumption with the former was 4.70 pounds, and with the latter 5.00 pounds.

Weights of the Animals.—Table XVII. gives the average weight of the pigs in each lot at the commencement of the experiment and at its close, with the total gain made by the pigs in each lot.

TABLE XVII.—Weights and Increase.

	Weight when the Experiment began.	Weight when the Experiment closed.	Total Increase.
	Lbs.	Lbs.	Lbs.
Lot 1.....	247	601	354
Lot 2.....	275	603	328
Lot 3.....	247	526	279
Lot 4.....	279	567	288
Total.....	1048	2297	1249

The evenness in the weights of the animals of each class at the commencement of the experiment is marked. Those in lots 1 and 3 of the first cross weighted collectively exactly the same. Those in lots 2 and 4 also weighed practically the same, as the difference in the aggregate weights is only 4 pounds. The total weight of the 6 pigs of the second cross was, however, 60 pounds more than that of the 6 pigs of the first cross, though exactly the same age and fed similarly. But at the end of the experiment this advantage was slightly modified. The 6 pigs of the second cross weighed together at that time but 43 pounds more than the 6 pigs of the first cross. In other words, the latter made more gain by 17 pounds than the former.

Table XVIII. gives the increase in weight made by the pigs in the several lots during the different periods of the experiment.

TABLE XVIII.—Increase During Each Period.

	1st Period.	2d Period.	3d Period.	4th Period.	Total.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Lot 1.....	39½	80	101½	133	354
Lot 2.....	41	72½	104	111	328
Lot 3.....	57½	44½	103½	73½	279
Lot 4.....	33½	64	87½	103	288
Average. ...	43	65	99	105	312

Three facts at least revealed by the above table should not escape notice. First, the increase made by the pigs in each of the lots was relatively small during the first period of the feeding, when 75 per cent. of the grain food was composed of oats. The small gains made during this period and the indifferent gains made during the next period, seriously cut down the daily average of the gains. Second, the gains increase as the proportionate quantities of the corn and barley fed increase, with the advancement of the experiment. The warm weather in the summer may have retarded the gains during the first and second periods, but making due allowance for this, the proportion of the oats fed would seem to be too large, and third, the 6 pigs to which corn were fed made together 115 pounds more increase than those to which barley were fed.

A statement of the daily average increase made, in several of its phases is now given:

	Lbs.
Average daily increase of the pigs in Lot 1.....	1.05
Average daily increase of the pigs in Lot 2.....	.98
Average daily increase of the pigs in Lot 3.....	.83
Average daily increase of the pigs in Lot 4.....	.86
Average daily increase of the pigs in all the Lots.....	.93
Average daily increase of the pigs of the first cross.....	.94
Average daily increase of the pigs of the second cross...	.92

Average daily increase of the pigs to which corn was fed..... Lbs. 1.02

Average daily increase of the pigs to which barley was fed..... .84

The average is not high with the pigs in any of the lots, and the reason has been given.

Table XIX. gives the cost of each food factor fed to the animals of the respective lots, and also the cost of these taken together.

TABLE XIX.—Cost of Food Consumed.

	Oats.	Corn.	Barley.	Green Food.	Total.
Lot 1.....	\$2.13	\$3.59	.....	\$0.12	\$5.84
Lot 2.....	2.32	3.78	.....	.11	6.21
Lot 3.....	1.91	.....	\$3.11	.10	5.12
Lot 4.....	2.86	.....	3.18	.11	5.65
Total.....	\$8.72	\$7.37	\$6.29	\$0.44	\$22.82

Oats were the most expensive, relatively, of all the foods fed, as will be apparent by referring to the estimated cost of the food. And so it has been in all our experimental feeding in the west. Because of this, however, we must not leap to the conclusion that they should not be fed at all in fattening animals.

This has not been proved. But until relative values change, they should certainly be used in such feeding with moderation. The lower cost of the barley ration gives only one phase of the story, as will be shown below.

Values and Profit.—Table XX. gives the value of the pigs in each lot when the experiment began and ended, the cost of the food fed, and the resulting profit.

The estimated value put upon the pigs when the experiment began was \$3.00 per 100 pounds. This may seem low but pigs were selling very cheaply throughout the entire year. Nor was it so low relatively as the selling price, which was only \$3.15 per 100 pounds. The profit on the 6 corn fed pigs was \$10.21, while that on the 6 barley fed

TABLE XX.—Values and Profit.

	Lot 1.	Lot 2.	Lot 3.	Lot 4.	Total.
Value on July 13th, when the experiment began.....	7.41	\$8.25	\$7.41	\$8.37	\$31.44
Cost of food.....	5.84	6.21	5.12	5.65	22.82
Total cost.....	\$13.25	\$14.46	\$12.53	\$14.02	\$54.26
Value on Nov. 2d, when the experiment closed.....	18.93	18.99	16.57	17.86	72.35
Profit.....	\$5.68	\$4.53	\$4.04	\$3.94	\$18.09

pigs was \$7.88. The difference in favor of the former was \$2.33. The profit on the 6 pigs of the first cross was \$9.72 and on the 6 pigs of the second cross \$8.37. The difference in profit in favor of the former was \$1.35. Too much, however, must not be made of this fact, as the value of the 6 pigs of the second cross when the experiment closed was \$36.85, while that of the 6 pigs of the first cross was \$35.50. The value of the former, therefore, exceeded the value of the latter by \$1.35. Notwithstanding that the pigs were precisely the same age, and that in all respects they had been similarly treated and fed, the profit made from feeding each animal for 112 days was \$1.51.

Cost of Increase.—The cost of making 100 pounds of increase was as stated below :

With the animals in lot 1	\$1.65
With the animals in lot 2	1.89
With the animals in lot 3	1.83
With the animals in lot 4	1.96
With the animals that were fed corn.....	1.77
With the animals that were fed barley.....	1.90
With the animals of the first cross.....	1.74
With the animals of the second cross.....	1.93
With the animals in all the lots.....	1.83

It would seem to be well nigh impossible to make pork at an average cost of \$1.83 per 100 pounds, and yet such was the outcome in an experiment which gave relative gains

that were only moderately good. Such a result emphasizes the extent of the advantage which the relatively low prices of food in the West give to the Western farmer who is also a grower of pork.

Disposal of the Swine.—At the close of the experiment the pigs were sold to the supply department of the School of Agriculture, and as stated previously, the price obtained was \$3.15 per 100 pounds. Prices had touched bottom at the time, hence though the sum received for them may seem very low, it was all that could have been obtained for them in the open market of the Twin Cities of St. Paul and Minneapolis. They were slaughtered by Mr. A. Boss in charge of the department which gives instruction to the students in dressing meats. He pronounced the quality of the meat as super-excellent. The proportion of the side meat was considerably larger than is usually found in Western pigs, the proportion of the lean to the fat was also greater, and the blending of the fat and lean was more perfect. It also made very pleasant and tender eating as may be attested by many competent witnesses in the locality. The proportion of lean in the pigs to which barley was fed was somewhat greater than in those to which corn was fed.

Financial Statement.—

Price received for the pigs on November 2nd, 1896, when the experiment closed	\$72.35
Estimated value of the pigs on July 13th, 1896, when the experiment began.....	\$31.44
Cost of food.....	22.82
Total outlay	54.26
Total net profit.....	\$18.09
Net profit on one animal.....	1.51

Observations.—1. It will be noticed that the food was estimated at average market values in the State. Ordinarily these would be in excess of the cost of production and there-

fore in excess of the home values. In this instance however the difference could not be much because of the very low cost of the food.

2. The value of the manure is supposed to offset the cost of labor, the cost of litter, and the interest on the money invested.

IMPORTANT FACTS SUMMARIZED.

Values—

1. Estimated value per 100 pounds when the experiment began, July 13th, 1896.....	\$3.00
2. Value per 100 pounds when the experiment closed, November 2d, 1896, on the basis of actual receipts.....	3.15
2. Advance in value per 100 pounds.....	.15

Weights—

	Lbs.
1. Average weight of the 6 pigs of the first cross when the experiment began.....	82
2. Average weight of the 6 pigs of the second cross when the experiment began.....	92
3. Average weight of all the pigs when the experiment began.....	87
4. Average weight of the 6 pigs of the first cross when the experiment closed.....	188
5. Average weight of the 6 pigs of the second cross when the experiment closed.....	195
6. Average weight of all the pigs when the experiment closed.....	192

Increase in Weight—

1. Average daily increase in weight of the 6 pigs of the first cross.....	.94
2. Average daily increase in weight of the 6 pigs of the second cross.....	.92
3. Average daily increase in weight of the 6 pigs which were fed corn.....	1.02

4. Average daily increase in weight of the 6 pigs which were fed barley.....	Lbs. .84
5. Average daily increase in weight of the pigs in all the lots.....	.94

Food Consumed—

1. Average daily consumption of food by each of the 6 pigs of the first cross.....	4.70
2. Average daily consumption of food by each of the 6 pigs of the second cross.....	5.00
3. Average daily consumption of food by each of the 6 pigs to which corn was fed.....	5.21
4. Average daily consumption of food by each of the 6 pigs to which barley was fed.....	4.50
5. Average daily consumption of food by each pig in all the lots.....	4.85

Cost of Increase—

1. Average cost of making 100 pounds of increase with the 6 pigs of the first cross.....	\$1.74
2. Average cost of making 100 pounds of increase with the 6 pigs of the second cross.....	1.93
3. Average cost of making 100 pounds of increase with the 6 pigs to which corn was fed.....	1.77
4. Average cost of making 100 pounds of increase with the 6 pigs to which barley was fed.....	1.90
5. Average cost of making 100 pounds of increase with the 12 pigs in the experiment	1.83

Increase in Value—

1. Average value of each of the 6 pigs of the first cross when the experiment began.....	2.47
2. Average value of each of the 6 pigs of the first cross when the experiment closed.....	5.92
3. Average increase in value of each pig of the first cross.....	3.45

- | | |
|--|--------|
| 4. Average value of each of the 6 pigs of the second cross when the experiment began..... | \$2.77 |
| 5. Average value of each of the 6 pigs of the second cross when the experiment closed..... | 6.14 |
| 6. Average increase in value of each of the 6 pigs of the second cross..... | 3.37 |

Profits—

- | | |
|---|-------|
| 1. Aggregate net profit from feeding 12 pigs for 112 days..... | 18.09 |
| 2. Average net profit from feeding one pig for the same period..... | 1.51 |

CONCLUSIONS.

The following stand prominent among the conclusions that may be drawn from the experiment:

1. That because of the low relative gains made by the pigs in all the lots during the first period of feeding, and because of the relative increase in the gains subsequently as the proportion of the oats fed was lessened, the conclusion would seem to be legitimate that a diet in which oats is a predominant factor is not the most suitable one that can be fed to pigs while being grown and fattened.

2. That because of the low consumption of food by the pigs to which barley was fed, the conclusion would seem to be legitimate that the free use of barley long continued in growing and fattening pigs tends to weaken the appetite at least to some extent.

3. That because of the low gains made by the pigs to which barley was fed, the conclusion would seem to be fair that a barley diet long continued is not quite so well fitted to make increase in weight as a corn diet, the other adjuncts being the same as in the experiment.

4. That since the pigs of the first cross made somewhat better gains and on less food than those of the second cross this experiment favors the view that they were a little more easily kept.

5. That because of the smallness of the difference in the relative gains of the animals of the two respective crosses, the experiment does not prove that one cross, as such, has any superiority over the other in capacity to make gains.

6. That with the prices of food and meat as in the experiment 100 pounds of pork may be produced at a cost of \$1.83 and yielding a profit of \$1.32.

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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

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DIVISION OF ENTOMOLOGY.

DECEMBER, 1898.

BUTTERFLIES AND MOTHS.

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BUTTERFLIES AND MOTHS

INJURIOUS TO OUR FRUIT-PRODUCING PLANTS.

Butterflies and moths are better known to the casual observer than other insects. The former, which are active only during the day, and which fly in the brightest sunshine, are frequently so beautifully colored as to well deserve the name "winged flowers." The term "*Lepidoptera*," which means scale-wings, is well chosen, as the insects belonging to the *Order of Lepidoptera* have both sides of their wings, as well as their bodies, more or less densely clothed with scales. These scales differ greatly in form and size, even in the same insect, and yet more so in the different groups, so that a certain family may even show forms peculiar to it alone. Some of these scales are not simply organs that serve as a protection to the wings proper, but they possess other functions as well, hence we find sometimes very highly developed scales on the wings of the male only, usually confined to very limited areas, or even concealed in folds. Scales are simply modified hairs, which, instead of growing long and slender, remain short and grow very wide. Every graduation in form, from hair to scale, can be found. If we capture with our fingers a butterfly or moth, and let the insect escape again, we find adhering to our fingers dust of various colors. If we look at this dust with a magnifying glass, we perceive at once that this glistening material is not simply dust, but that it is composed of scales rubbed off the wings and body of the captured insect. Numerous beautiful and highly-colored scales of different shapes are thus seen. When we study the wings from which these scales are removed we see that such scales are arranged as regularly as the scales on a fish, or the shingles on a roof, and we can also detect how the beautiful markings on the wings are produced. A glance through a microscope will show us that the colored spots and lines on the wings are

made by grouping together colored scales in the same way as we frequently see upon the roofs of barns the year of their erection in colored shingles which strongly contrast with the neighboring ones of different colors. Part of a wing, with some of the scales removed, as well as some of

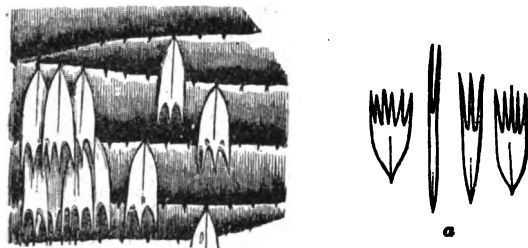


Fig. 1.—Part of wing, showing arrangement of scales:
a, individual scales. Greatly enlarged. After Packard.

the scales, is shown in Fig. 1. The scales covering these insects doubtless strengthen and ornament the wings, and protect as an armor the body and legs. If we study the colors and markings of a lepidopterous insect, we can well imagine that both serve almost opposite purposes, both protect the insect, it is true, but in a different manner. In most cases the colors and markings are such that if the insect is at rest, they blend with the colors of the surrounding objects. Persons that are in the habit of seeking for insects of this order, notwithstanding that they soon have their eyes thoroughly well trained, are frequently misled

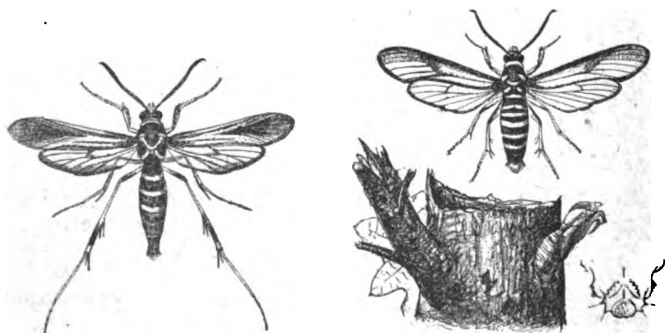


Fig. 3.—Clear-wing moths resembling wasps. Original.

and do not perceive the insect right "under their eyes" until it moves. This is a case of "*protective colors*." Fig. 2, plate I, shows some geometric moths thus protected. Other colors are "*warning colors*." In this case the butterfly or moth either possesses the form and color of a stinging insect, Fig. 3, or it has colors found upon insects not eaten by birds. Moths having such warning colors do not hide, but expose themselves very openly upon some object that contrasts strongly with their colors and thus they become very plainly visible.

The Milkweed butterfly (*Danais archippus* Fab.) Fig. 4, plate I., belongs to a genus of butterflies which are not eaten by birds, very likely because they are poisonous or otherwise offensive, hence these showy insects, being thus well protected, are very common wherever their food plants occur. The Disippus Butterfly (*Limenitis disippus* Gtd.) belongs to a genus of butterflies very palatable to birds, yet notwithstanding this it escapes, being no doubt mistaken for the unpalatable Milkweed Butterfly, which it so closely resembles. Compare Fig. 5, plate I. with Fig. 4 of the same plate.

The wings themselves consist of two thin, translucent or transparent membranes, which are kept apart by hollow, horny tubes, the *ribs*, *costæ* or *nerves*; the form of the wings is usually triangular, possessing therefore three margins, the *anterior*, *interior*, and *exterior* or *posterior* margin (Fig. 6). The space where the fore-wings join the body is called the *basis*. The shape of the wings depends upon the ribs or veins, which have received by scientists special names, as well as

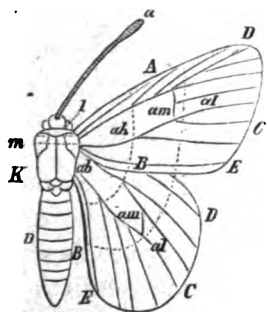


Fig. 6.—Wings: A, anterior margin; B, interior margin; C, exterior or posterior margin.

the spaces or cells they enclose. The classification of lepidoptera is mainly based upon the arrangement of such veins and cells.

The *mouth-parts* of moths and butterflies are only adapted for sucking nectar from flowers, and not for chewing their food. The main part is a long sucking-tube (Fig. 7, *h*), composed of two greatly elongated *maxillæ* fastened together side by side; as each maxilla is furnished with a

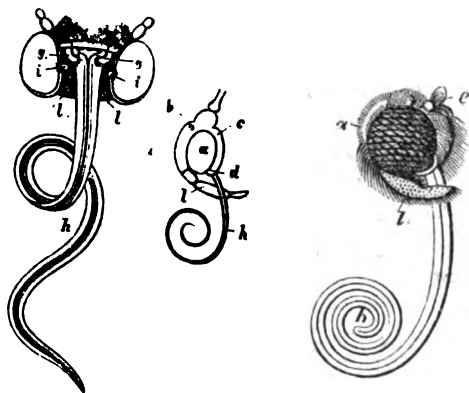


Fig. 7.—Head: *a*, compound eye; *h*, tongue; *l*, labial palpi. Enlarged.

groove the two *maxillæ* fastened together form a perfect tube by means of which the liquid food is conveyed to the mouth and stomach. Usually this tongue is quite smooth, but in some cases its tip is furnished with spines, which enable the insect to rupture the skin of ripe fruit to obtain its juice. As many moths do not eat they lack a tongue, or possess only a rudimentary one. This important organ, when not in use, is curled up like the mainspring of a watch, and is hidden and protected by the labial palpi (Fig. 7, *l*), which for this purpose project forward. Moths and butterflies, in extracting nectar from flowers, become very useful in pollenizing them; some plants, indeed, have to depend altogether upon these insects for their continued existence.

The *compound and unmovable eyes* (Fig. 7, *a*) of lepidoptera, are large and composed of many small facets, each of which is a perfect eye. This arrangement enables the insect to look in many directions at the same time. These com-

pound eyes are either globular or oval; they are naked or covered with short hairs, but in some cases we find long and lash-like hairs.

The *antennæ* or *feelers* vary greatly in their shape, and form a very important organ for classification. They are composed of many joints, from 30 to 100; they vary not alone in shape and length in the different families, but even the sexes of one and the same moth may possess entirely different antennæ, those of the male being frequently toothed, etc., while those of the female are simple. The antennæ are sense organs, hence highly organized and important for the insects, which become disabled if they are removed. The illustration (Fig. 8) shows a number of differently formed antennæ.

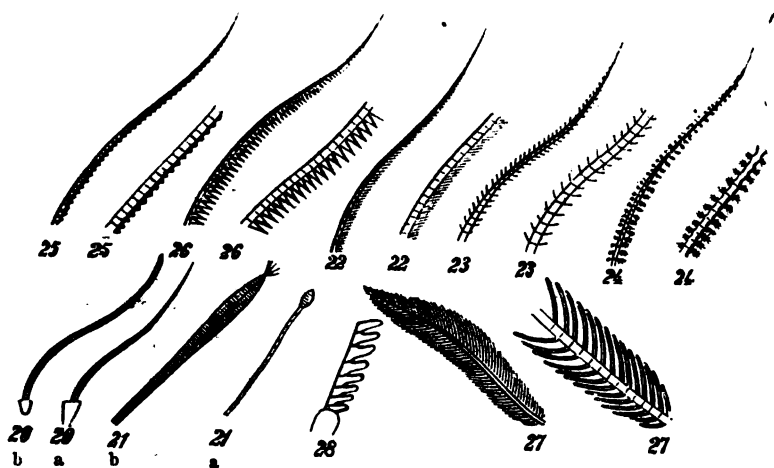


Fig. 8.—Antennæ or feelers. Enlarged.

The *legs* are not always perfect, but in some families of lepidoptera they are more or less aborted. In Fig. 9 we have both perfect and imperfect examples. Cases occur where the legs are entirely absent, at least in the female sex, as shown in the Bag-worm described later.

The *metamorphosis* of this order of insects is complete, and we can hardly imagine a greater difference in form than



Fig. 9.—Legs. Enlarged.

that between the *egg*, *caterpillar*, *pupa* and *imago* of the same insect. (See Figs. 16 and 19).

The *eggs*, which are always, if possible, deposited upon or near the food needed by the caterpillars or larvæ, are of many different forms. A few are shown in Fig. 10. They

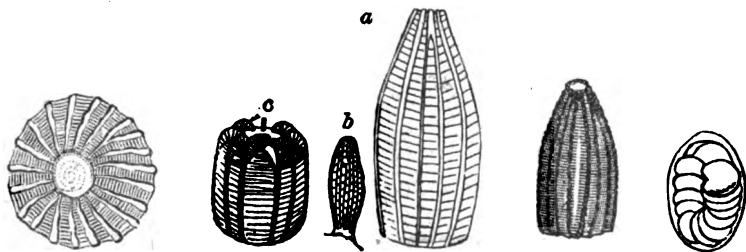


Fig. 10.—Different kinds of eggs.

vary also in color, though most of them are greenish, or greenish-white. Some eggs are quite smooth, others are beautifully ornamented with numerous ribs or other projections; some are deposited singly, others in more or less regular masses, sometimes carefully covered with glue or scales. Some eggs hatch in a very short time after being deposited, while others remain for half a year exposed to all

kinds of weather before they show any changes previous to hatching. These changes consist in a darkening of the eggs; in some cases, where the shell is thin, we can observe the gradual formation of the enclosed embryo, as shown in the illustration. As soon as ready the young caterpillar eats its way through the shell, and sometimes the very first meal it enjoys in the open air is the very egg-shell that protected it before.

Caterpillars, which are the second state in the existence of all butterflies and moths, vary in every conceivable manner, as may be seen by studying the illustrations in the text. Usually, however, they are cylindrical beings, composed of head and twelve *rings* or *segments*. The *head* (Fig. 11), is the most specialized part of the larva; it is usually horny, since the muscles moving the powerful chewing organs are fastened to it *internally*. The illustration shows that it is separated by a central line (a) into two equal parts. The

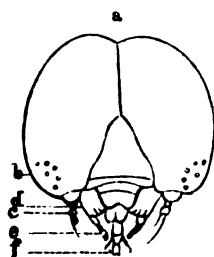


Fig. 11.—Head of caterpillar; b, ocelli; c, antennæ; d, mandibles; e, maxillary palpi; f, labial palpi. Enlarged.

triangular *clypeus*, the small *ocelli* (b), the *antennæ* (c), the *upper lip* or *labium* with the horny *jaws* or *mandibulæ* (d), are also shown. The *under lip* or *labium* is not seen, but the four-jointed *maxillary-palpi* (e), and the two-jointed *labial palpi* (f) are shown. At the end of the labium is located a very important organ, the *spinning-tube*, through which the substance flows that is used by the caterpillars to make the protecting

silken cocoons. The caterpillars differ very greatly from the adult insect by possessing a biting and not a sucking mouth, hence they can become very destructive to agriculture, horticulture and forestry by consuming plants which we intend to use ourselves. The first three segments of a caterpillar behind the head are the *thoracic segments*, and to them are fastened three pairs of *jointed feet*, which later transform into those found in the winged insect; the other segments

are called *abdominal segments*, and these form later the abdomen of the adult or imago. The abdominal segments carry the *false legs* or *prolegs*, which disappear in the butterflies or moths. Such prolegs are not jointed but are equipped with rings of hooks that enable the caterpillar to grasp securely the object on which it moves; the last segment is usually distinguished by a pair of prolegs formed somewhat differently from the others. Most caterpillars possess, including the true legs, sixteen legs, but the loopers or measuring worms have only ten, and those living in bags but six. All caterpillars, or worms looking like caterpillars, which possess more than sixteen legs, are not the larvæ of lepidoptera, but are those of saw-flies, insects belonging to the order of Hymenoptera. Such worms are called "*false caterpillars*." Upon the first thoracic segment of a true caterpillar we find quite often a horny plate; this is the *cervical shield*, used in throwing off the head-plate when the insect is

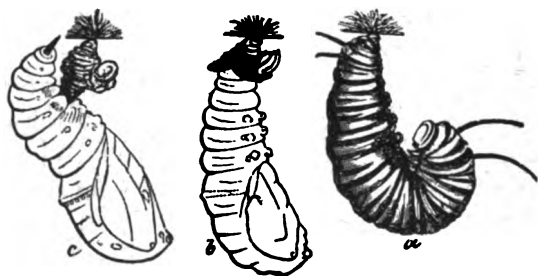


Fig. 12.—Moulting of the caterpillar of *Danais archippus*; a, larva suspended; b, pupa still partly in larval skin; c, pupa in the act of leaving the skin entirely. After Riley.

moulting; another plate, the *anal-shield*, occurs frequently upon the last segment. The *breathing-pores* or *stigmata* occur as small openings upon the sides of the body. Not all caterpillars are cylindrical, however, and forms occur that resemble in external shape sow-bugs or slugs. Some caterpillars are densely covered with hairs, sometimes arranged in tufts or brushes; others are only clothed with a few hairs, or with spines, while still others are naked.

Some can cause more or less inflammation by means of urticating or stinging hairs or spines, but none are really poisonous. Many caterpillars are brilliantly colored, or are ornamented with bright, longitudinal or vertical stripes, or with spots of various shapes and colors. Most are terrestrial, none really aquatic, and but few consume animal food. They grow by throwing off their old skins from three to five times, a process that is called *moulting*. This process is a very interesting one, as may be seen by studying the illustration in Fig. 12, commencing at *a*.

As soon as the larva, worm or caterpillar has reached its full size, it transforms to a *pupa* or *chrysalis*, which is unable to move or to eat, lacking in this form both legs and mouth. It appears to be dormant, but in reality is quite active, as all the organs simply foreshadowed in larva or pupa have to be changed into the very different organs found in the imago. In other words the biting mouth of the larva has to be changed into the sucking mouth of the moth; the small and simple eyes or ocelli have to be transformed into compound eyes; the small legs are made longer, and the external organs and wings are produced during this apparent rest. The internal organs are also very greatly altered; the large stomach of the caterpillar is reduced to almost nothing, and in its place appear the reproductive organs, as eggs, etc. There are many different kinds of pupæ, some of which are shown in Fig. 13, and those familiar with the study of lepidoptera can tell at a glance to what families

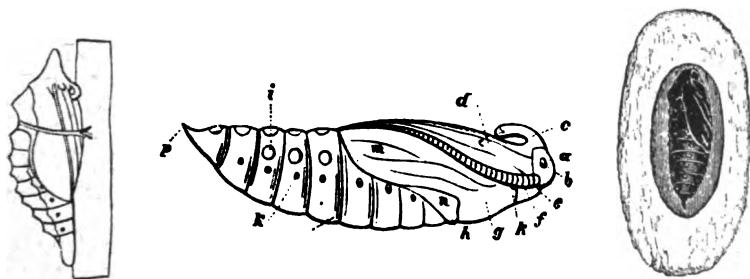


Fig. 13.—Pupa of butterfly, hawk-moth and owl-moth.

they belong. Some pupæ are found suspended, others are enclosed in a silken or earthen cocoon, while still others are found in a smooth cell in the earth.

After remaining in this condition for a shorter or longer time, the *imago* or *perfect insect* leaves the pupal skin through an opening in the back. At first the wings are very minute, being folded up in numerous wrinkles; but they expand very rapidly, and as soon as the tubes or veins in the wings are filled with air, and the skin covered with scales is fully expanded and dried, the insect can fly about, a thing of beauty, and a very different being from a crawling caterpillar.

More than six thousand species of lepidoptera have been described from North America, north of Mexico, which represent more than sixty families. In order to give a synopsis of the lepidoptera, it would be necessary to enter into rather difficult technical details, and a bulletin like this is not the proper place to do so, hence those that wish to study this order more in detail are referred to such valuable works as those published by Comstock, Packard, Smith and others.

In a rather crude way we divide the lepidoptera into two groups, into *Butterflies* and *Moths*, the *Rhopalocera* and *Heterocera*. These terms are derived from the form of the antennæ of these insects; *Rhopalocera* are those in which the antennæ terminate in a more or less distinct knob or club at the tip, and in which at least the front pair of wings are elevated and vertical when at rest, so that the upper surfaces touch, as may be seen in the illustration of *Grapta* (page 68). The *Heterocera* possess feelers of many different kinds, none of which are distinctly clubbed; their wings, when at rest, are horizontal, folded on the back and close to the sides, oblique, roof-like or spread out flat, but never habitually vertical. Usually butterflies are active during the day, while moths are night-flyers; this is a rule which has, however, many exceptions, as some moths fly during the day.

The *Butterflies* separate readily into groups based on the character of the feet and the situation of the antennæ.

The so-called "*true butterflies*" are distinguished by having the antennæ set close together on the top of the head, this being rather narrow; the antennal club is abrupt at the tip, and not drawn into hook or recurved. In the *skippers*, the head is broad, the eyes are comparatively small, the antennæ are widely



Fig. 15.—Skipper.

separated, set close to the eyes, and terminate in a pointed tip, which is often recurved or hooked. Fig. 16 shows a true butterfly, and Fig. 15 a skipper or Hesperid. A large series of the true butterflies is distinguished by having the anterior pair of feet more or less aborted or imperfect, as is shown in Fig. 9. To these "*brush-footed*" butterflies belong two families, the *Nymphalidæ*, which contain medium or large sized species, and the *Lycænidæ*, small species, usually blue or coppery in color, and frequently called "*blues*" or "*hair-streaks*." Members of the family *Papilionidæ* are large and showy butterflies, whose anterior feet are perfectly developed in both sexes. To this family belong the large "*swallow-tails*" and insects like the cabbage-butterflies.

The Moth or *Heterocera* are much more difficult to classify, and the reader interested in such matters is referred to the text-books. But usually we divide the Heterocera into Hawk-moths (*Sphingidæ*); Clear-winged moths (*Sesiidæ*); Wood-nymph moths (*Agaristidæ*); Woolly-bears (*Arctiidæ*); Vaporer or Tussock moths (*Lymantriidæ*); Slug-caterpillars (*Limacodidæ*); Bag-worms (*Psychidæ*); Prominents (*Notodontidæ*); Royal moths (*Ceratocampidæ*); Silk-spinners (*Bombycidæ*); Borers (*Cossidæ*); Owlet-moths (*Noctuidæ*); Span-worms (*Geometridæ*). Butterflies and moths are frequently called Macro-lepidoptera or large lepidoptera, while all the others are called Micro-lepidoptera or small lepidoptera. These latter are also divided into numerous families, such as the (*Pyraustidæ*); Pyralids (*Pyralidæ*); (*Phycitidæ*); Bee-moths (*Galleriidæ*); Crambids (*Crambidæ*); Feather-moths (*Pterophoridæ*); Leaf-rollers or

Bell-moths (*Tortricidæ*); (*Chonchilidæ*); (*Grapholithidæ*); and Tineids (*Tineidæ*), to which belong numerous families of such insects as leaf-miners, cloth and fur-moths, grain-moths, etc.

As this bulletin is mainly written for the use of the horticulturist, it is impossible to make it at the same time a text-book, hence only those insects are described in detail, that cause injuries to our fruit and fruit-producing plants. But for the sake of the general student a number of illustrations have been added that will at least show other lepidopterous insects not described in detail, yet necessary to give an idea of the classification of this order of insects. Only well known or destructive species have been selected for this purpose.

BUTTERFLIES.

(*Rhopalocera*).

FAMILY NYMPHALIDÆ OR FOUR-FOOTED BUTTERFLIES.

These butterflies are also called "brush-footed;" they differ from all others in our fauna in having the fore-legs very greatly reduced in size in *both* sexes. The legs are so much dwarfed that they can not even be used for walking, but are folded against the breast like a tippet.

THE MILKWEED BUTTERFLY OR MONARCH.

(*Danais archippus* Fab.).

This well known large butterfly, with reddish-brown wings marked with black veins and white spots, is very abundant in late summer and fall. It sometimes gathers in large armies about our wind-breaks, just previous to migrating south, where it spends the winter. The caterpillars, which grow to about an inch and a half in length,

are greenish marked with black bars, and are furnished with rather long, black, hair-like tentacles; they feed upon the common milkweeds. As this insect is very common, and can easily be raised in captivity, those that wish

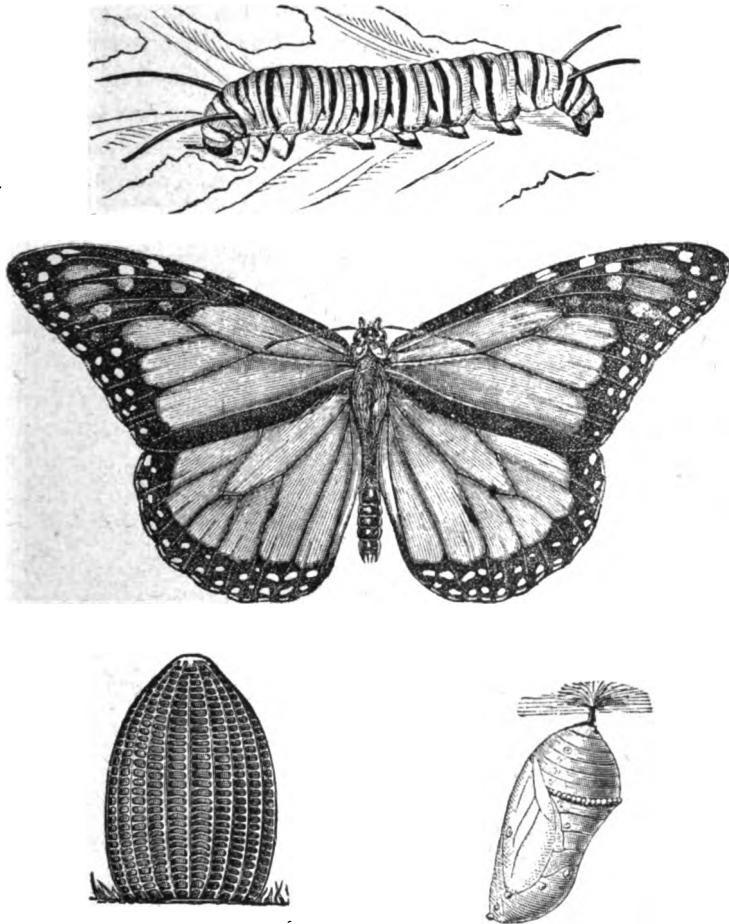


Fig. 16.—*Danaus archippus* Fab.: Egg, caterpillar, pupa and adult. After Riley.

to see for themselves the metamorphoses of insects can do so without much trouble. All that is necessary is to furnish the caterpillar with a fresh supply of food whenever needed. Before long the caterpillar will fasten itself by

means of its hind feet to a little pad of silk, and will change to a chunky, bright-green pupa or chrysalis, marked with small golden spots, one of the most beautiful objects that can be imagined. This color gradually becomes darker, finally brown or blackish and then the butterfly will emerge. This insect is not injurious, but simply illustrated to serve as a type of the family to which it belongs. The illustrations, Figs. 12 and 16, give all the stages of this insect.

THE SPINY OR THORNY CURRANT CATERPILLAR.

(*Grapta comma* Harr.).

These peculiar caterpillars are sometimes quite numerous, denuding whole canes of the currant and gooseberry bushes. When this is the case, the plant suffers greatly and we find that the injured canes do not produce fruit in the



Fig. 14.—*Grapta comma* Harris. Original.

following season. The parent of this thorny caterpillar is a very handsome butterfly (Fig. 14), also shown on plate II, Fig. 17. The wings are quite irregular in outline, having many projecting points and notches; they measure, when expanded, about one inch and a half. The surface of all four wings is reddish-brown, bordered on the outer edge with

darker brown, and on the disk with brown and blackish-brown spots. The color of the hind-wings varies considerably in intensity, and this is still more so the case with the color of the underside, which is usually, however, dark-brown, with many grayish lines and streaks. A number of varieties have been described on account of these differences. But the butterfly can always be recognized from the fact that it has upon the lower surface of the hind-wings a more or less plainly marked "C" of metallic silver. From this mark the butterfly is frequently called the "C" butterfly. It passes the winter in the winged or adult state in some sheltered spot, in which it remains torpid, but awakens to fresh activity as soon as the warmth in spring imbues nature with new life. It, with some other nearly related species, can be found during the first days of spring flying about in sunny spots. Its flight is peculiar and rather jerky and swift; it darts suddenly away and as suddenly returns, occasionally resting on the sunny side of a tree, and here displaying the bright colors of the wings, somewhat dulled in intensity, however, by the influence of winter. The butterfly has the habit of exposing the entire surface of its wings as if proud of their beauty; then, again, it closes them and becomes almost invisible, as the color of the underside of the wings blends exceedingly well with the color of the bark upon which it rests; in fact, these butterflies are so well protected on this account, that when at rest it requires a keen eye to detect them at all. During the summer, when the butterflies enjoy perfect health, they sometimes seem to invite us to chase them. If one is disturbed and flies off from the spot it occupied, it is certain to return to that exact spot in a short time. The insect feeds upon any sweet fluid, but prefers the sap from any freshly wounded tree.

The eggs are usually laid singly on the leaves of the currant and gooseberries, and here the solitary caterpillars may be found. When full grown, they are about an inch

and a quarter long, varying in color from a light brown to a greenish-yellow; they are marked with fine black and yellow lines. The numerous spines clothing the caterpillar are branched and differ in color, some being dark brown, others orange or yellow, the branches of the spines are frequently tipped with black. Notwithstanding the forbidding and threatening aspect of these caterpillars they can not inflict any injury to our hands. As soon as the full size has been reached, the caterpillars select some secluded spot in which to change to pupæ or chrysaldis. They spin for this purpose upon a leaf or a twig a minute pad of silk. In this little carpet the hind leg of the caterpillar are fastened, after which it hangs suspended with the head downwards. In the course of two or three days, after contracting greatly in length, the old skin is shed, and an angular looking chrysalis of a brown color appears, which is finely ornamented with silvery spots. In about ten days the butterfly appears in all its beauty.

We have in Minnesota two annual generations of this insect; the first appears late in June and the second late in August and during September.

The caterpillars of this insect feed also upon the hop, elm, nettle, false nettle and basswood, but prefer wild and cultivated gooseberries and currants.

Other closely allied species of *Grapta* also feed occasionally upon the cultivated currants and gooseberries, but as their habits are almost identical with that of *comma*, it is not necessary to describe them.

REMEDIES.—Hand-picking is in most cases all that is needed to keep this insect in check. In cases where we have to fight at the same time other injurious insects of the currant and gooseberry, it would be best to use a little London-purple or Paris-green. Of course none of these poisonous substances should be used at a time when the fruit is ripe or nearly ripe.

THE RED ADMIRAL.

(*Pyrameis Atalanta* Linn.).

This, like the Grapta just described, belongs to the "Angle-wings" or butterflies distinguished by having the outer margin of the fore-wings usually decidedly angular or notched, as if a piece had been cut away. This beautiful butterfly has purplish-black wings above; on the fore-wings

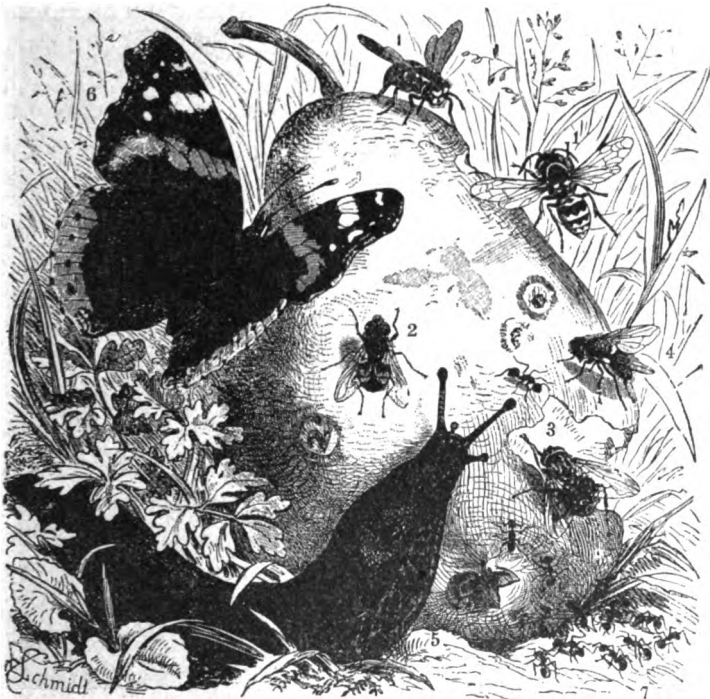


Fig. 18.—*Pyrameis atalanta*, and other insects, etc., feeding on overripe pear.

there is a bright orange-colored band, beginning near the middle of the front margin and extending nearly to the inner angle; between this and the tip of the wing are several white spots. On the hind-wings there is also an orange band on the outer margin, enclosing a row of black spots. The

under surface of the wings is also ornamented in a similar way, but is fainter, and especially that of the lower wings resembles the bark of trees. Faintly marked upon them are the figures 98 89.

This beautiful insect feeds as a caterpillar upon the nettle and hop, but in the winged state it is a great admirer of fallen and overripe fruit. It is attracted in large numbers to fallen apples or pears, and is not slow to absorb their sweet sap with its tongue. Other butterflies are also attracted, as well as ants, flies, and wasps as shown in the illustration (Fig. 18), and even snails are fond of it.

THE URSULA OR SOVEREIGN.

(*Limenitis ursula* Fab.).

During the months of June and July we may see a most beautiful butterfly flying about cherry and plum trees, evidently in the act of depositing eggs. This medium-sized and handsome insect is of a sombre bluish-black or blackish-brown color, having the wings bordered with blue; the under-wings possess marginal rows of bluish crescents of varying size; the inner row in the female is less marked, and each crescent is supported behind by a deep orange patch or point. Several white spots occur near the tips on the upper surface of the fore-wings. All the margins of the wings are slightly crenate, the hollows being edged with white. The under side of the wings, which measure about three inches across, contain a number of large brownish spots. The females deposit eggs upon the leaves of the wild and cultivated cherries, plums, and occasionally of the apple. The mature caterpillars are about an inch and a quarter long, of an olive-green color, variegated with white, russet, reddish-yellow and ochreous. They possess two long reddish horns behind their heads, and two green tubercles on each of the other segments, with the exception of those on the fifth,

which are reddish. The very strange looking chrysalis is russet, marked with white; it is suspended by its tail, and has on the middle of its back a curious and prominent projection like a Roman nose. Besides the food-plants given above, the caterpillars feed also upon the willow, scrub-oak, whortleberry and gooseberry.

The Ursula Butterfly or Red-spotted Purple is not a common insect, and the injuries caused by it are usually

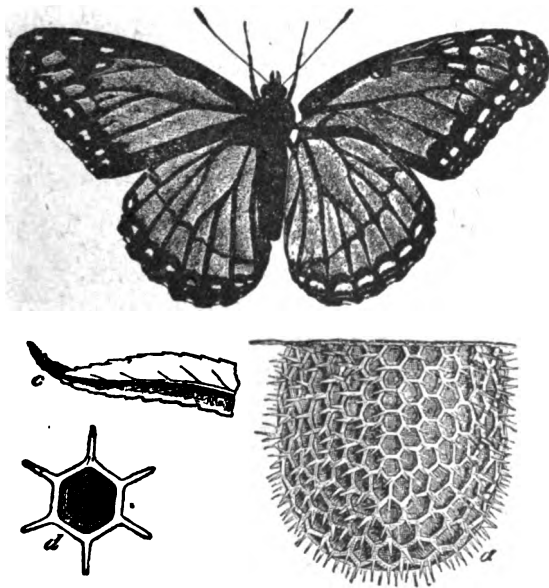


Fig. 19—*Limenitis disippus*, adult; a, egg, greatly enlarged. c, egg, natural size; d, one of the pits, still more enlarged. After Riley.

slight. Still it sometimes happens that for some reason this species becomes very numerous, stripping the leaves from an entire tree. The butterfly is shown in Fig. 22, plate III.

Further north a closely related species, the Banded Purple, is sometimes very common. Its caterpillar feeds upon the wild cherries. At Lake Vermillion the writer has seen this species, the (*Limenitis arthemis* Dru.), so numerous that during June hundreds of them could be found in the

roads, where, like many other butterflies, they are attracted by liquid manure. They are so eager for this substance that they return immediately to it if driven off. The *Limenitis arthemis* is at once distinguished from the *ursula* by the possession of a white band over each wing, upon both upper and lower surfaces. (Fig. 2, plate III).

A third species, much more common than either, is the well-known Disippus Butterfly or Viceroy (*Limenitis disippus* Godt.). The larva of this insect occurs in large numbers on our willows. Here the young caterpillar winters over in a little self-made cell or *hibernaculum* (Fig. 20, c). Occasionally the caterpillar is also found feeding on the leaves of the plum tree.



Fig. 20—*Limenitis disippus*; a, caterpillar; b, chrysalis; c, hibernaculum.

The Disippus Butterfly (Fig. 5, plate I and Fig. 19) resembles very closely the large milk-weed butterfly shown in Figs. 4 and 16, and as the latter is not eaten by birds this similarity in color and markings is a good protection, and as a result of this the Disippus is much more common than the closely allied species not thus protected. It is of a warm, orange-red color, with heavy black veins, and a black border with white spots. Fig. 20 shows the caterpillar and chrysalis of *disippus*; those of the two other species resemble them very closely.

FAMILY LYCÆNIDÆ OR GOSSAMER-WINGED BUTTERFLIES.

All members of this family are small and delicate butterflies, with slender bodies, delicate and bright-colored wings, and antennæ usually ringed with white. A very remarkable character of this family is that in the female the front legs are normal, while in the male they are shorter, without tarsal claws, and with the tarsi more or less aborted.

The caterpillars are more or less slug-like, and one of them has the peculiar habit of being carnivorous. A large number of butterflies belong to this family. Some are distinguished by their orange-red or brown colors, with a coppery reflection; others have the upper surface of their wings of a delicate blue, while still others are dark, with delicate, hair-like streaks upon the lower surface of the wings. The butterflies are, on account of these characteristics, frequently called the "Coppers," the "Blues," and the "Hair-streaks."

THE CHERRY-TREE THECLA.

(*Thecla titus* Fab.).

This delicate butterfly belongs to a small group of pretty butterflies which are very seldom seen, common as some of them are. They are best observed if we watch the flowers of the different kinds of milkweeds, but especially those of the butterfly-weed (*Asclepias tuberosa*). Many butterflies visit these showy flowers, and among them a number of different kinds of the genus *Thecla*, which are easily recognized by their jerky and erratic flight. In the northern part of the state the above-named butterfly is at times very common. It differs from our other species of *Thecla* by the absence of the hair-like tails on the hind-wings, and by the fact that the wings of the male butterfly differ in shape from those of the female. The butterfly is of a dark brown color above, with a row of seven or eight

orange-colored spots near the margin of the hind-wings, which are larger and more conspicuous on the under than on the upper side. The wings beneath are lighter brown, with a row of deep but bright orange spots near the hind margins of both pairs, an inner and more irregular row of small black spots, encircled with white, and on the middle of the hind-wings two similar spots, placed close together. The wings, extended, measure about an inch and a quarter across.

The caterpillars of all species of this genus are peculiar beings. That of *titus* is a curious flat creature, of a dull green color, with a yellowish tint, a patch of rose color on the anterior segments, and another larger one on the posterior extremity; the head is small and of a polished black color. The caterpillar resembles a common wood-louse or sow-bug in outline.

The chrysalis is pale-brown, and somewhat glossy, with numerous, minute, dark-brown or blackish dots over the whole surface. It is thickly covered with very short brown hairs, scarcely visible to the eye.

This interesting butterfly, illustrated in Fig. 23, plate III, occurs sometimes in large numbers towards the end of July. The caterpillars feed upon the leaves of wild and cultivated cherries, plums and oak, but they are not numerous enough to cause much damage.

THE BANDED HAIR-STREAK.

(*Thecla calanus* Hub.).

This beautiful butterfly is not common in Minnesota. The upper surface of its wings are dark brown, with brassy-green reflections. The hind-wings have two very unequal, thread-like tails, of which the lower one is the longest; it is also edged with white. The base of the fringes, from the anal angle to the lower tail, is white, and at this place there

is also a narrow, white terminal line. The under side of the wings is very prettily marked, and is somewhat paler than the upper one. There are two short, whitish, parallel lines on the disk of the fore-wings, and a whitish crenate line crosses the wing about half way between the last and outer borders, shadowed within by blackish; there is another broken, whitish line shaded on the outside with blackish, between the last line and the outer border. The under side of the hind-wings have two short, whitish, discal lines with a blackish shade between them. A series of blackish spots, edged on either side with whitish, crosses the wing beyond the disk; and outside of this is a series of lunate, whitish spots, shaded on the outside with blackish, and faintly edged on the outside, below, with bluish-white. Along the anal angle the black streak is followed with orange. At the very apex of the anal angle there is a black spot with white on its upper side. On the next interspace is a patch of powdery blue scales, and in the next interspace to this is an orange crescent enclosing a black spot. The orange scales are also faintly visible in the next interspace.

The caterpillar feeds on apple, oak, and other plants. The butterfly (Fig. 24, plate III) measures with expanded wings an inch and a quarter across.

THE STREAKED THECLA.

(*Thecla strigosa* Harr.).

“Upper side of the wings dark brown and unspotted in the males, but the females sometimes have a fulvous spot near the anal angle of the hind-wing and are paler in color. The under side of the wings is pale reddish-brown. The outer part of both wings is crossed by four, irregular, rather wavy, white lines, varying a little in individuals, but the two inner ones on the fore-wings approach each other towards the hinder margin. The third is shorter than the

second, and the fourth or outer one, reaches only to the middle of the wing. The inner line on the hind-wings ex-



Fig. 25.—*Thecla strigosa*
Harr.

tends nearly across, then bending, runs some way up the hinder margin, preceded in the last part of its course by another nearly parallel to it. Above the termination of these two, there is a circlet of white on the margin. The outer line is short, and limited to the middle of the wing. The fore-wings have a sub-marginal row of indistinct brown lunules edged on the inside with white, and the hind-wings have a similar series, which are bright red

towards the anal angle, and edged on the inner side with black followed by white, and enclosing next to the anal angle, a large black space which is nearly covered with blue scales. Beyond this is a small black spot, and there is another at the angle surmounted by a red stripe edged like the lunules, and extending up the margin. The lunules next the apex usually exhibit a few scales of red. The margins of both wings are edged with a fine whitish line.

“Body fuscous, beneath grayish-white. Legs, white, annulated with brown. Palpi, white, the outer joint black tipped with white. Antennæ annulated with black and white. Club, fuscous tipped with white.”

The larva was taken by Mr. Saunders on a species of thorn (*Cratægus*), and his description is as follows: “Length, half an inch. Head, greenish-brown. Body flattened, sloping abruptly at the sides. Color, velvet-green, with a darker colored dorsal stripe. The anterior edge of second segment, yellowish-brown with a few darker dots; the middle segment laterally striped with two or three faint, yellow, oblique lines, and the last two segments have each a lateral yellow patch, and there is a faint, yellow basal line from the fifth to the terminal segments. Under surface, bluish-green.

"The larva is .37 of an inch long, nearly oval, and with the head case rounded. The body is dark reddish-brown, with black markings, and thickly covered with fine hairs. The anterior segments have many black patches on them, and there is a dark ventral line from the sixth to the twelfth segments." This species is shown in Fig 25.

FAMILY PAPILIONIDÆ OR SWALLOW-TAILED BUTTERFLIES.

This family contains the giants of the butterflies, and is well represented in our state by a number of large and bright species. The butterflies belonging here have all their

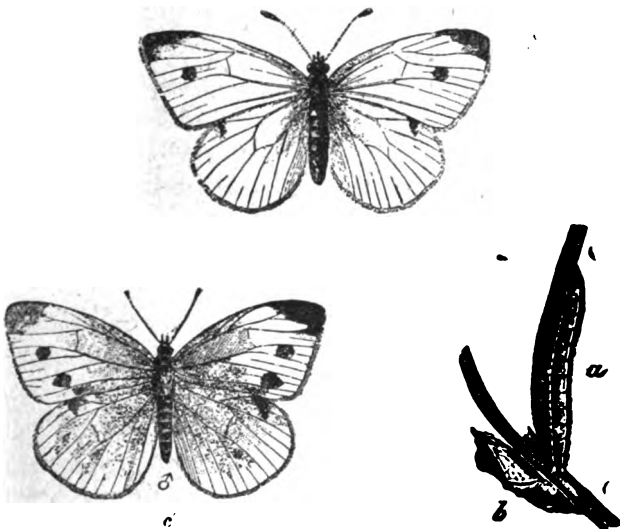


Fig. 26.—Cabbage butterflies. After Riley.

legs perfect in both sexes, and the antennæ are set close together at the base. There are two groups, the first one containing such insects as the injurious cabbage-butterflies (Fig. 26), and the second one the true swallow-tails.

THE TURNUS SWALLOW-TAIL

(*Papilio turnus* Linn.).

Among the numerous kinds of North American swallow-tailed butterflies few are as beautiful as this species, which leisurely sails through the warm air of June and July. It is not a common insect, excepting in the lake region of our State. In the northern part of Minnesota, but chiefly near Lake Vermillion, it occurs in countless numbers, and sometimes the shores of the lake are simply lined with a broad band of these gaudy beings. They are attracted by all sorts of putrid matter, and a dead fish seems to possess special attractions. This butterfly is, with one exception, the largest swallow-tail found in Minnesota, and measures with expanded wings four inches and more. The wings in all our specimens are a rich lemon-yellow, banded and bordered with black; on the fore-wings are four black bars, the inner one extending entirely across the wing, the outer ones becoming shorter as they approach the apex. The front-margin is edged with black, and the outer-margin has a wide border of the same color, in which is a row of eight or nine spots, the lowest one being the smallest. The hind-wing is crossed with a tapering streak of black; there is also a wide black border enclosing lunar spots. Above and about these spots, and especially towards the inner angle of the wing, this border is thickly powdered with blue scales. The outer margin of the hind-wing is scalloped, and partly edged with yellow; the inner-margin is bordered with brownish-black for about two-thirds of its length, followed by a small yellow patch, which is succeeded by a larger black spot, centered with a crescent of blue atoms, and bounded below by an irregular reddish spot margined within with yellow. The hind-wings terminate in two long black tails, edged on the inside with yellow. The body is black above, margined with pale yellowish. The paler under-surface of the wings is similar to the upper one.

In Minnesota both sexes of this beautiful butterfly have a yellow ground color of the wings; but south of Pennsylvania the female usually loses this color and becomes almost black; the male, however, always retains its normal yellow color.

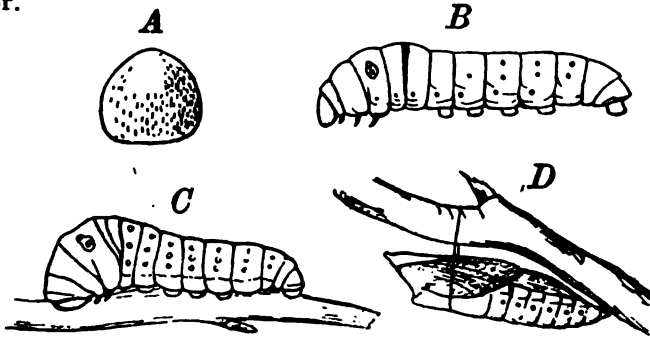


Fig. 28.—*Papilio turnus*, Linn.: A, egg; B, larva crawling; C, larva resting; D, chrysalis.

The winter is passed as a chrysalis (Fig. 28, D.), which is of a dull brown color; it has a conical horn back of the head. Towards the end of May the butterflies appear; they now commence to deposit their eggs upon the leaves of apple and cherry trees; in the north they prefer the cherry and the canoe-birch for this purpose. The eggs are laid singly, and hatch in about twelve to fourteen days. The very young caterpillars are black, roughened with small brownish-black tubercles, with the first segment thickened, of a dull, glossy, flesh-color, a prominent fleshy tubercle on each side, and a patch of white on the seventh and eighth segments. Fully grown, the caterpillar is about two inches long, with a rather large reddish-brown head, and a green body, paler on the sides, which tapers posteriorly; parts of the body are covered with a whitish bloom. On the front edge of the first segment is a raised yellow fold, which slightly overhangs the head, and from which, when irritated, the caterpillar can protrude a yellow, fleshy and forked organ, which gives off a peculiar odor, disagreeable to some persons. No doubt this peculiar organ, found near the head

in the caterpillars of most swallow-tails, though in caterpillars of some moths near the tail, has the office to drive off the numerous parasites always ready to pounce upon their victims. On each side of the third segment is an eye-like spot, nearly oval, yellow, enclosed by a ring of black, centered with a small elongated blue dot, which is also set in black. In some species of swallow-tails these eye-like spots look very much like eyes, and are sometimes quite startling. Another raised yellow fold occurs on the posterior portion of the fourth segment; it is bordered behind with velvety black, but is only seen when the caterpillar is in motion. Other dots occur as indicated in the illustration (Fig. 28).

Early in August, the caterpillar becomes restless and wanders about in search of a suitable spot in which to change to a chrysalis, and in which to pass the winter. When such a shelter has been found, it spins a little carpet of silk, into which it fastens the hooks of the prolegs; it then fastens a silken band or loop around the middle of its body to suspend itself. This done, it casts its larval skin and remains as a chrysalis until the following spring.

The butterfly is shown in Fig. 27, plate IV.

FAMILY HESPERIDÆ OR SKIPPERS.

These butterflies are quite different from all the preceding ones; they differ by possessing broad heads, clothed with bristly hair, by having widely separated antennæ, the clubs of which terminate by a more or less marked and recurved slender hooklet, and by having rather small wings in comparison to the heavy bodies (Fig. 15). They are very well named, as they skip from place to place amongst low herbage. The caterpillars have unusually large heads, with strongly contracted necks; they generally make a sort of nest of a folded leaf or of several leaves. We have a large number of species in Minnesota, but none are destructive to fruit; most of the caterpillars feed upon the leaves of the various kinds of clovers, vetches and similar plants. A common species is shown on Plate IV, Fig. 29; it is the silver-spotted skipper (*Endamus tityrus* Fab.).

MOTHS.

(Heterocera).

FAMILY SPHINGIDÆ OR HAWK-MOTHS.

Hawk-moths are easily recognized by the form of the body, wing and antennæ. The body is very stout and spindle-shaped; the wings are long, narrow and very strong; the antennæ are more or less thickened in the middle or towards the tip, which is frequently curved back in the form of a hook; rarely are the antennæ pectinated. The tongue is usually very long, being in some instances twice as long as the body; but in one subfamily it is short and membranous. When not in use it is closely coiled like a watch-spring beneath the head.

Hawk-moths, or Humming-bird moths, have obtained these names from their habits of hovering about the flowers, and from their rapid and darting motions. Most of them appear just about dusk, flying about such deep flowers as the morning glories, primroses, petunias or others. By means of their unusually long tongues they are enabled to reach the very bottoms of these flowers in which are located the nectaries, taking this food while poised over the flower, and but rarely alighting. This attitude, and the whirl of their powerful vibrating wings, gives them a strong resemblance to humming-birds, which obtain the sweet food in a similar manner. Some of the smaller and clear-winged hawk-moths fly during the broad daylight.

The caterpillars of the Sphingidæ are all external feeders, and have a cylindrical and naked body, usually with a horn near the end on the eighth abdominal segment; in some cases this horn is replaced by a shining tubercle or knob. Many people are greatly afraid of such caterpillars, believing that they could inflict painful wounds with these horns, which

are, however, never provided with stings. While at rest many of the caterpillars assume a very peculiar attitude, supposed to resemble the Egyptian Sphinx, hence their scientific name Sphingidæ.

THE THYSBE CLEAR-WING.

(*Hemaris thysbe* Fab.).

This beautiful insect is not as common as the closely related Bumble-bee Hawk-moth (*H. diffinis* Bdv.), the larva of which frequently strips all the foliage from our ornamental waxberry plants and honeysuckles. Both moths fly during the day and resemble very closely the common bumble-bees, both in size and general appearance. The wings of *thysbe*, which expand nearly two inches, are transparent, and crossed by dark brown veins. The fore-wings have a narrow costal border, a wide outer border dentate inwardly on the inter-spaces, and a basal patch extending along the hinder margin, of a dark, reddish-brown color, and overlaid on the basal portion with olive-green hairs. This species is readily distinguished from our other species by a line of scales dividing the discal cell lengthwise. The hind-wings are bordered all around, narrowly on the costa, more widely on the outer margin, with dark, reddish-brown, while the hinder margin and base of the wing have a very wide border of rusty red.

The trim-looking caterpillar, nearly one inch and three-fourths in length, tapering towards the head, is of a pea-green color, granulated, with dark breathing-pores; a pinkish stripe extends along the middle of the back, bordered on each side with a whitish line, which ends in front of the caudal horn. A white or yellowish line runs along each side from the second segment to the base of the horn, which is curved, light-blue, tipped with yellow, granulated with white on the sides, and black in front.

The pupa is blackish-brown, with the entire surface shagreened. The terminal spine is broad at the base, prominent, flat, rounded at the tip, and armed with some fine hooks.

The caterpillars feed upon different kinds of snow-balls, waxberry, hawthorn, apple and plum.

The adult insect is shown in Fig. 30, plate V.

THE GRAPE-VINE AMPHION.

(*Amphion nessus* Cram.).

This beautiful moth (Fig. 31) is found from time to time flying about from the first to the middle of June in broad sunlight, and in this way resembling the insect just described. Specimens were caught here as late as the beginning of August.

The moth, which expands from one inch and three-fourths to two inches, has the upper side of head, thorax,



Fig. 31.—*Amphion nessus* Cram.
After Beutenmueller.

abdomen and fore-wings of a dull, dark, rusty-brown color. The middle of the fore-wings is crossed by a rich, dark-brown oblique band, within which are two lines of the same color; beyond the central band is another line followed by several spots of the same color. None of the markings are clearly defined. The fringes are of the same color as the wings, except at the middle of the excavations, where they are pale yellow. The hind-wings are of a rich, dark brown color, with an oblique, central reddish band; the fringes are pale yellow, spotted with brown.

The caterpillar, which feeds upon the grape-vine, Virginia creeper, *Epilobium*, and some other plants, measures

over two inches in length; it tapers greatly from the fourth segment to the head, but there is a slight enlargement of the third and fourth segments which increases with every moult. It is of a uniform pale yellowish-green color, or chocolate-brown, dotted with numerous dark-umber points, but especially along the dorsal line; two light longitudinal subdorsal lines extend straight from the head to the eleventh segment, thence curving to the caudal horn. There are also eight lateral or stigmatal stripes of dark umber; the caudal horn is very short, black-ochre or reddish-brown at the base, tapering abruptly, and often carried in a line with the back. The caterpillar is rather sluggish: at rest it stretches itself at full length along the leaf or leaf-stem, very much like the larva of the Abbot Spinx described later. When full grown it transforms to a dark-brown pupa under the rubbish on top of the ground.

THE ABBOT SPINX.

(*Thyreus Abbotii* Swains.).

This interesting insect is not common in Minnesota, but occurs only occasionally upon our cultivated and wild grapes, as well as upon the Virginia creeper. The caterpillar reaches its full size early in August, when it measures almost two inches in length. It varies considerably in color and appearance. Usually it is of a dull yellow or reddish-brown each segment being marked transversely with six or seven fine black lines, and longitudinally with dark brown patches, giving the caterpillar a checkered appearance. The under side of the caterpillar is yellowish, with a pinkish tinge between the prolegs. The head is slightly roughened and dark, with a lighter broad band each side, and a central x-shaped mark down the middle. This caterpillar does not possess the usual caudal horn like the other larva of the Sphingidæ, having in its place a polished black tubercle, ringed with

yellow; nor does it assume the usual attitude of a shinx by holding up the head, but rests stretched out at full length upon a twig. If disturbed it will throw its head from side to side, producing at the same time a crepitating sound.

The pupa is formed most frequently in a little cavity on the surface of the ground, or is simply hidden under a few dead leaves or other rubbish loosely fastened together with threads of silk, in which are mixed grains of earth. The pupa, about an inch and a quarter long, is of a blackish or dark brown color, roughened by confluent punctures, but between the lighter colored joints it is smooth. The head-case is broad and rounded; the tongue-case does not project; and the tail terminates in a rough, flattened and wedge-shaped point, from which extend two minute horns.

The adult insect remains in the ground until the following spring, hence we have but a single annual generation. The peculiar moth, measuring with expanded wings about two and a half inches across, is of a dull chocolate or grayish-brown color. The front-wings are lighter beyond the middle, and are variegated with brown. The hind-wings are sulphur-yellow, with a broad, dark brown border breaking into a series of short lines on a flesh-colored ground as it approaches the body. The wings are very deeply scalloped, especially the front ones. The body, which is curved upwards when the insect is at rest, is furnished with tufts along the sides near the extremity. If the insect should ever become common, it is easily kept in check by hand-picking. A number of small parasites seem to make it their business to keep it from increasing.

This insect is shown in Fig. 32, Plate V.

Deidemia inscripta Harris.

This is a very uncommon hawk-moth, not alone in Minnesota but everywhere, and although it feeds as a caterpillar on the grape-vine and Virginia-creeper, it is not apt

to become injurious. This caterpillar is about two inches long, of a fine green color; its caudal horn is whitish at the tip; the head is small and the body tapers from the third segment towards the head. It enters the ground late in June or in the beginning of July for pupation, but not very deeply, and here it remains until the middle of May, when the moth emerges; there is but a single annual brood.

The moth, which expands a little less than two inches, has an ashen-gray head and body; the thorax is shaded with brown, and there are two rows of dark brown spots on the abdomen. The last segment is trifurcated; the antennæ are



Fig. 33.—*Deidemia inscripta* Harr. After Beutenmueller.

serrated in the male, simple in the female. The fore-wings have the same color as the body, with bands and marks of rich brown of various shades; there is a pale discal spot, and also a small triangular spot near the exterior margin. The hind-wings are reddish, or reddish-brown, with darker outer margins. The under side of the wings is ashen-gray, with darker borders; the small triangular white spot on the upper surface near the outer edge of fore-wings is repeated.

This rare moth is shown in Fig. 33.

THE WHITE-LINED MORNING-SPHINX.

(*Deilephila lineata* Fab.).

This very beautiful moth is quite common in Minnesota, and would cause much more injury to our cultivated grape-vines if it did not prefer the common purslane for food, to

which it is quite welcome. The moth may often be seen at dusk flying from flower to flower. It resembles in its flight a humming-bird, especially if it hovers over some flower and pushes its long tongue into the same to extract the sweet nectar found in it. The humming-sound, similar to that produced by the flight of a humming-bird, is produced by the rapid motion of the wings.

The ground-color of the fore-wings of this hawk-moth is a rich greenish-olive, with a pale-buff stripe or bar extending along the middle of the wing from the base to near the tip; along the outer margin there is another band nearly equal in width, but of a grayish color; the veins are margined with white. The hind-wings, which are quite small, are of a roseate color, and are marked above and below by an almost black band; the lower margin is fringed with white. On the body there is a line of white on each side, extending from the head to the base of the thorax, where it unites with another line of the same color, which extends down the middle, and dividing, sends a branch to each side. The greenish-olive abdomen has interrupted bands of white and black, as shown in the illustration Fig. 36, Plate VI. The wings of this fine moth expand about three inches and a half.

This insect is double brooded in Minnesota, appearing on the wing in June and again in September. It seems as if an attempt was made to produce still another brood, as not infrequently the moths are found very late; Sept. 28 and Oct. 14 are dates of late captures.

This moth has a very wide geographical range, being not alone found throughout the United States, but also in Canada, West Indies, Mexico and Southern Europe, where it is called (*D. livornia*). Its caterpillar is a rather general feeder, having been found upon the grape, apple, watermelon, buckwheat, turnip and purslane; the latter is the plant preferred, however. It is not uncommonly found as late as September, even up to frost. When mature, the

caterpillar enters the earth, where it forms a smooth cavity, inside of which it transforms to a light-brown pupa. The caterpillars vary very much indeed, so much so that extreme forms of it do not resemble each other in the least. The most common form is yellowish-green, with a prominent sub-dorsal row of elliptical spots, each spot consisting of two curved black lines inclosing a bright crimson space and a pale yellow line; all the spots are connected by a pale yellow stripe, edged above with black (Fig. 34). The other



Fig. 34.—*Deilephila lineata* Fab., caterpillar.



Fig. 35.—*Deilephila lineata* Fab., caterpillar.

common form is black, distinguished chiefly by a narrow yellow line along the back, and a series of paler and darker yellow spots (Fig. 35). Both forms are subject to great variation.

These rather beautiful caterpillars are sometimes exceedingly numerous, and people are apt to become scared on their account. When army worms and migratory locusts have denuded fields of almost all plants, only the purslane is left in undisturbed possession of such fields, not having been eaten by either of the above insects, and having now an opportunity to spread, this weed is not slow to do so, and in this way a large amount of food is offered to and accepted by this insect. But an increased number of caterpillars is

soon followed by an increased number of parasites, from which this species of moths suffers greatly. A two-winged fly, a species of *Tachina*, destroys large numbers of the larva, and it is often quite difficult to find a single caterpillar that does not show the cream-white eggs of this parasite.

THE DARK-VEINED MORNING SPHINX.

(*Deilephila galii* var. *chamænerii* Harr.).

This is a closely allied species, but smaller and not as common, though by no means a very rare insect. Its larva has also been found feeding upon the leaves of the grapevine, but it prefers those of plants belonging to the genera *Galium* and *Epilobium*. Other plants are also eaten. The moth has the same greenish-olive color as *lineata*, and almost the same stripes and markings. The central band on the fore-wings in this species is wider and more irregular; the thorax lacks the white markings on the disk, and the veins are not lined with white. The hind-wings in both species are almost identical in coloration and markings. This insect is quite common in Europe, and the form found here hardly deserves the name of a variety. It is shown in Fig. 37, Plate V.

The caterpillar, measuring about two and a half to three inches in length, has a small dull-red head, with a black stripe across the front at base. The body is deep olive-green, polished, with a pale yellow line along the back, terminating at the base of the caudal horn; on each segment, from the third to the twelfth, is a pale yellow spot on each side, about half way between the dorsal line and the breathing-pores, largest on the segments from the sixth to the eleventh; the spot on the twelfth segment is elongated, and, extending upwards, terminates at the base of the horn. The yellow spots are placed in a wide but indistinct blackish band, and the sides of the body below the spots are thickly

sprinkled with minute, raised, yellow dots. The under surface is pale pinkish-green; the feet are black; the prolegs pink; with a patch of black on the outside of each.

THE ACHEMON SPHINX.

(*Philampelus achemon* Drury).

Among the fifty or more larvæ of moths that feed upon the foliage of the grape, we have some ten species of hawk-moths, all of which are widely distributed. Some of them are rare, but others will occasionally become quite destructive. The best known of all is the caterpillar of the above-named Sphinx, which frequently devours all the foliage of the Virginia creepers, and strips whole canes of the grape. Being quite large it is readily seen, and it is always a case of gross negligence if such a large insect is not discovered and removed. In nurseries the damage is frequently very great, as one of the large caterpillars can kill numerous young vines in a short time. Hand-picking is in all cases the most simple and satisfactory remedy.

The full grown caterpillar of this insect is usually found towards the latter part of August and early in September. It is a large larva, measuring almost four inches when crawling; at rest it measures much less, as the first two smaller segments are partly withdrawn in the much larger third segment. The caterpillar varies in color from pale straw-color to reddish-brown, the color growing darker and deep-brown towards the under side. An interrupted line of brown runs along the back, and another unbroken one extends along each side; below this latter are six scalloped cream-colored spots, one on each segment, from the sixth to the eleventh. The much wrinkled body is dotted with minute spots, which are dark on the back but lighter and annulated at the sides. Head, thoracic segments, and spiracles are suffused with flesh-color; the prolegs and

caudal-plates are brown. When this caterpillar is ready to change to a pupa it changes to a beautiful pink or crimson color. The young larva is green, with a long and slender horn rising from the eleventh segment and curving over the

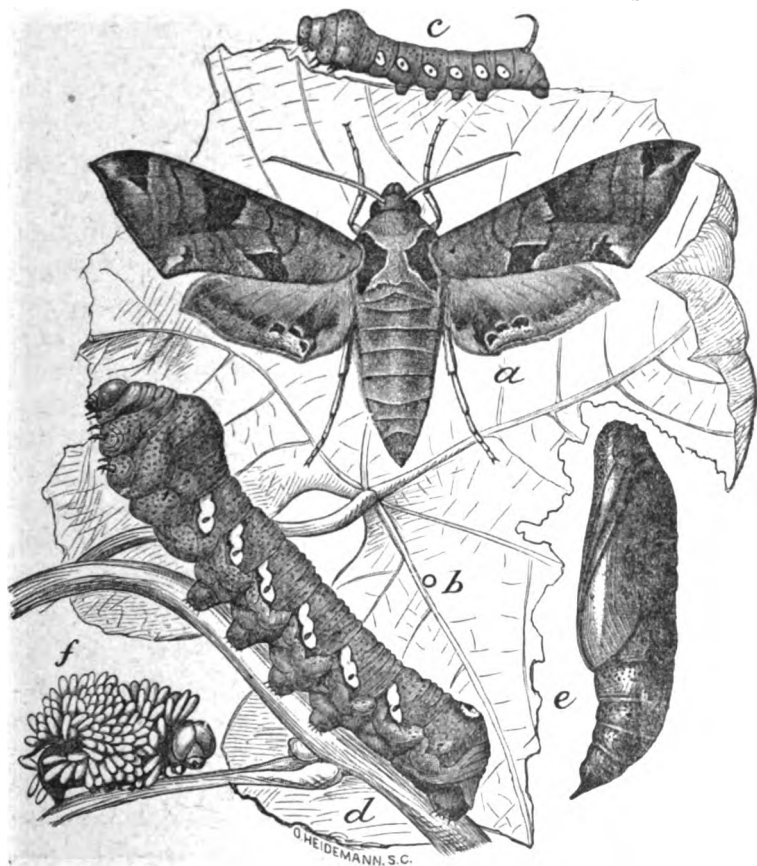


Fig. 38.—*Philampelas achemon* Drury. a, moth; b, egg; c, young larva; d, mature larva; e, pupa; f, parasitized larva—all natural size. From Div. of Entomology, Department of Agriculture.

back. In the older and fully grown specimens this long horn has disappeared, and in its place is found a highly polished lenticular tubercle.

The large pupa is formed in a smooth cell several inches below the surface of the ground; it is of a dark, shining

mahogany color, shagreened or roughened, especially at the anterior edge of the segments on the back, and terminates in a short, blunt spine. This species is single brooded, and the pupa remains in the ground until late in June of the following year, though in some cases the moth has appeared the same season.

The fine looking moth is brownish-gray, variegated with light brown, and with deep brown spots. The hind-wings are pink, with a dark shade across the middle, still darker spots below this shade, and a broad gray band behind. The heavy reddish-gray body is marked with two dark brown triangular patches on the thorax, which are finely edged with white. The posterior edges of all the segments of the body are also edged with white.

This showy insect is found throughout the United States and Canada, or wherever the grape is cultivated, or where the Virginia creeper is utilized to decorate our dwelling places.

The illustration (Figs. 38) shows the different states of this insect; the adult and caterpillar is also shown in Figs. 39 and 40 on Plate VII.

THE PANDORUS SPHINX.

(*Philampelus pandorus* Hbn.).

One of the most beautiful moths found in the United States is the Pandorus Sphinx. It is not common in Minnesota, but occurs here, as several specimens have been seen that were captured in our State. The moths, with wings fully expanded, measure from four to four and a half inches across; they are of a light olive color, mixed with gray, and varied with patches of a darker olive-green, rich and velvety, and some portions, especially on the hind-wings, are of a rosy hue. The body is pale greenish-brown, ornamented with dark olive patches. The moths appear in July, when, after pairing, the female deposits her eggs singly on

the leaves of the grape-vine and Virginia creeper (*Ampelopsis quinquefolia*), where they shortly hatch, producing small green larvæ of a pinkish hue along the sides and with a

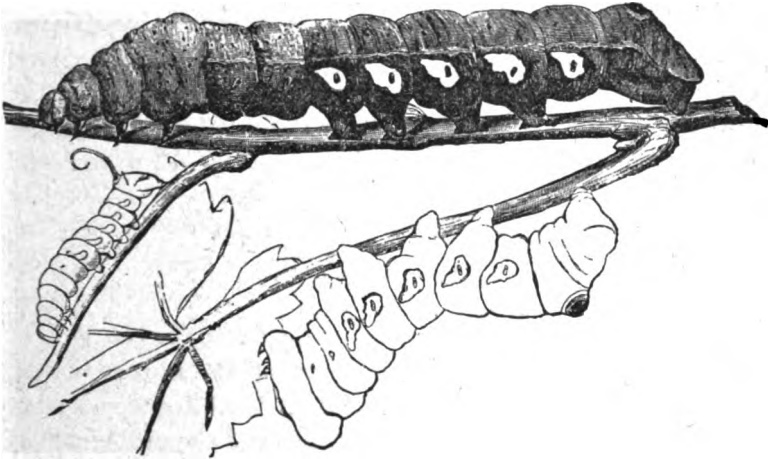


Fig. 41.—*Phyllampelus pandorus* Hbn. Caterpillars of different ages. After Riley.

very long pink horn at the tail (Fig. 41). As the caterpillars increase in size the horn becomes shorter, and after a time curves round. As the larva approaches maturity, it changes to a reddish-brown color, and after a third moult loses the caudal horn, which is replaced by a glassy, eye-like spot. The mature larva, when in motion, will measure nearly four inches in length, but when at rest it draws the head and two adjoining segments within the third, which shortens its body nearly an inch, giving it a very odd appearance, with its anterior portion so blunt and thick. It is of a rich reddish-brown color, of a lighter shade along the back, with five nearly oval cream-colored spots along each side from the seventh to the eleventh segments inclusive. On the anterior segments there are a number of black dots; a dark, polished, raised, eye-like spot in place of the tail; the breathing-pores along the sides black, showing prominently in the cream-colored spots. It is a very voracious feeder,

and strips the vine of its leaves with such rapidity that it soon attracts attention. When full grown it descends from the vine and buries itself in the ground, where it forms an oval cell, within which it changes to a pupa. This pupa is of a chestnut-brown color, with the segments roughened with impressed points, the terminal joint having a long, thick spine. The insect remains in the pupal state until the following summer, but occasionally it matures and escapes the same season. The moth is shown in Fig. 42, Plate VII.

THE HOG-CATERPILLAR OF THE GRAPE.

(*Ampelophaga myron* Cram.).

This common caterpillar, also called the "Green Grape-vine Sphinx," is the most destructive of the horned caterpillars found feeding upon the foliage of the grape. It is called the Green Grape-vine Sphinx because the moth, which expands about two and a half inches across the wings, has the fore-wings of a dark olive-green color, crossed by bands and streaks of greenish-gray, and shaded on the outer-margin with the same hue; its hind-wings are dull red, with a patch of greenish-gray next the body, shaded gradually into the surrounding color. On the under side the red appears on the fore-wings, the hinder pair being greenish-gray. The antennæ are dull white above, rosy below; head and shoulder-covers deep olive-green, the rest of the body of a paler shade of green; underneath the body is dull gray. The moth is shown in Fig. 43, Plate VI.

It rests quietly during the day, takes wing at dusk, and is very active, having a swift and strong flight. It darts rapidly from flower to flower, and is not readily captured, as it is a wide-awake insect. Large numbers are attracted to the electric lights, and the moths fly enormously long distances to it, otherwise they could not be found at this light in our prairie villages, and in places where neither grape-vines nor Virginia creepers are grown.

The caterpillars consume a very large amount of food, and a very few of them are capable of stripping a small vine of its foliage in the course of two or three days. They possess the additional bad habit of gnawing into the stems of the clusters of the grapes, which either wilt or drop off.

The eggs, which are 0.05 inch in diameter, perfectly round, and of a uniform delicate yellowish-green color, hatch



Fig. 44.—*Ampelophaga myron* Cram., caterpillar. After Riley.

into pale green worms with long and straight horns at the tails. After feeding from four to five weeks they reach their full size, and the horns look now comparatively short, with a posterior curve. The full grown (Fig. 44) caterpillar is distinguished by having the third and fourth segments immensely swollen, while the first and second ones are quite small and retractile. According to Prof. Riley it is from this peculiar appearance of the fore part of the body, which strikingly suggests the fat cheeks and shoulders and small head of a blooded hog, that it is known as the "Hog-caterpillar." Perhaps an equally good explanation for having this name is the great appetite possessed by such worms. The color of a grown caterpillar is pea-green; it is wrinkled transversely, and covered with numerous pale yellow dots, placed

in irregular transverse rows. An oblique cream-colored lateral band, bordered below with darker green, and most distinct on the middle segments, connects with a cream-colored sub-dorsal line, which is bordered above with darker green, and which extends from the head to the horn at the tail. There are five and often six somewhat pale yellow triangular patches along the back, each containing a lozenge-shaped lilac-colored spot. The head is small, with yellow granulations, and four perpendicular lines, and the spiracles or breathing-holes are orange-brown. The caterpillars vary considerably in coloration, especially those of the second brood, where the green is often replaced by a delicate reddish-pink, with markings of darker shades of red and brown. When full grown the caterpillar descends from the vine, and among old leaves or any other rubbish lying

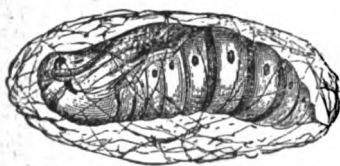


Fig. 45.—*Ampelophaga myron* Cram., pupa. After Riley.

on the ground it forms a mesh of strong brown silk, within which it changes to a pupa (Fig. 45), which is of a pale brown color, speckled and spotted with brown, but chiefly characterized by conspicuous dark brown

spiracles and broad brown incisures of the three larger abdominal segments.

The moths of the first brood appear during May; those of the second late in July. The insect passes the winter in the pupal state.

The best method to dispose of these pests is to pick them off the vines, and as the worms are readily detected by the ravages they cause this remedy is very simple. Though frequently very numerous, their numbers are kept in check by several parasitic insects. It is not uncommon to see one of these caterpillars covered with snow-white cocoons of a minute wasp (Fig. 46). These co-



Fig. 46.—*Ampelophaga myron* Cram., caterpillar parasitized.

coons are frequently mistaken by those not well posted in such matters for the eggs of the caterpillars themselves. Of course this is a mistake, as caterpillars are not in the habit of laying eggs. If the poor victim of these parasites, which can no longer take any food, is kept in a glass, we shall soon



Fig 47.—Parasite.

see what will become of those reputed eggs. Before very long we shall see that a very minute wasp (Fig. 47) pushes open a little lid, which it had previously cut with its jaws, and flies off, happy to be liberated from its narrow cell. As all caterpillars

attacked by these parasites succumb in the end, and never transform to pupæ, it is well to recollect that worms carrying such egg-like cocoons should be left alone, and should by no means be destroyed. The small wasps issuing from these cocoons have nothing else to do but to search for other caterpillars in which to deposit their eggs, hence they are employed in very good work.

THE PLUM-TREE SPHINX.

(*Sphinx drupiferarum* S. & A.).

Like all the members of the Sphinx moths, the above insect possesses a robust body, and long and narrow wings moved by powerful muscles, which enable it to fly rapidly over long distances. This accounts for the fact that they are found frequently at electric lights many miles away from their place of birth.

The Plum-tree Sphinx (Fig. 48, Plate VI) is a handsome insect, but quite different from those described before, as it lacks their bright colors. The moth, which appears during June, has an expanse of wings measuring from three and a half to four inches. The wings are of purplish-brown color; the fore-wings have a stripe of white on their anterior edge, and one of a fawn-color on their outer one; there are also

three or four oblique black streaks, and a black dot on the white stripe. The hind-wing has two whitish, wavy stripes, and a fawn-colored one on the outer edge. The head and thorax are blackish-brown, with a whitish-fawn color at

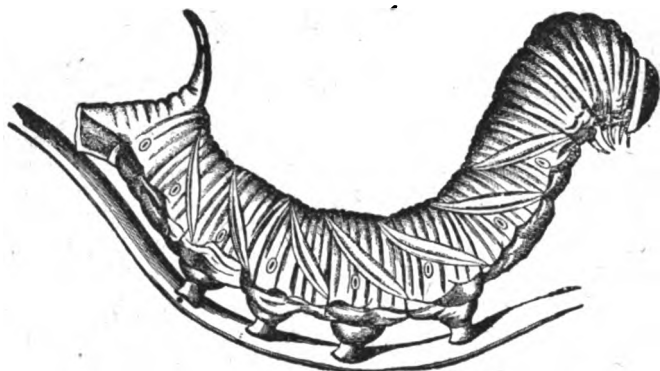


Fig. 49.—*Sphinx druplerarum* S. & A.; caterpillar. After Saunders.

the sides; the eyes are very prominent; the snout-like projection in front consists of the two palpi, within which lies the tongue, snugly coiled up like the spring of a watch. This tongue is as long as the body and is used by the insect in extracting nectar from flowers. The body is brown, with a central line and a band on either side of black, the latter containing four or five dingy-white spots. The insect is quite common in Minnesota, as indicated by the large number of moths attracted to the electric light. Even as far north as Duluth the insects occur in fairly large numbers.

The eggs are laid singly on the leaves of the plum. They are of a pale yellowish-green color, smooth, slightly oval, and about one-fifteenth of an inch long. In about eight days the young caterpillar eats its way out through the side of the egg; the shell itself is usually eaten in part or entire. The young larva is of a pale yellowish-green color, with a few slightly elevated whitish tubercles on every segment, from each of which arises a single short hair; the caudal horn is dark. When full grown the caterpillar (Fig. 49) is

about three and a half inches long, of a beautiful apple-green color, and with a lateral dark-brown or blackish stripe. On each side of the body there are seven broad, oblique, white bands, bordered in front with light purple. The breathing-pores are of a bright orange-yellow; the dark-brown horn is quite long and has a yellowish tint about the base at the sides.



Fig 50.—*Sphinx drupiferarum*
S. & A.; pupa.

When not feeding this larva assumes the peculiar rigid position that has given this class of caterpillars the name of "Sphinx." It is quite a formidable looking insect, but is perfectly harmless and can be handled with impunity.

As soon as fully grown, it enters the ground, where at the depth of several inches it prepares a large and smooth cell, lined with some sort of water-proof cement, and there it changes to a reddish-brown pupa, about an inch and a half long, and with a short, thick and projecting tongue-case (Fig. 50). The pupa remains in the ground until the following June.

Like all worms of this kind they soon show their presence upon plum trees by the denuded twigs, and a vigilant fruit-grower should not be slow to find and exterminate this foe. Sometimes these caterpillars cause considerable damage in nurseries, and if found in large numbers, as is sometimes the case, many young plum trees are killed.

THE APPLE SPHINX.

(*Sphinx gordius* Cram.).

This moth (Fig. 51, Plate VI), which expands from three to three and a half inches across the wings, is also found in Minnesota, but seems to be rather uncommon. It is found from late in May to the end of June. Its fore-wings are dark

brown, varied with ash-gray, with black streaks within the veins, and a white dot near the middle, resting on a long black line. The hind-wings are gray; a band across the middle, and a wide marginal band are black. The fringes of the wings are white, the head and thorax blackish-brown. The abdomen is dark-gray, with a central black line, and alternate black and grayish bands partly encircling it.

The caterpillar of the Apple Sphinx, like most others of this family, is thick, cylindrical and apple-green, about two and a half inches long, with a reddish-brown horn projecting from the hinder part of its back, and with seven oblique stripes along each side, of a violet color, margined behind with white. This caterpillar also enters the earth for pupation, and changes to a brown pupa with a short projecting tongue-case. The insect winters as a pupa.

Hand-picking is all that is needed to keep this insect in check.

THE BLIND-EYED SPHINX.

(*Paonias excæcatus* S. & A.).

Among the numerous caterpillars that infest apple trees, we find sometimes a thick and cylindrical worm, about two and a half inches long, which differs from all those mentioned thus far by having a green and triangular head, bord-

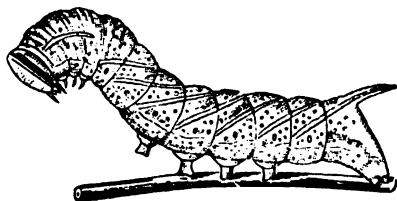


Fig. 52.—*Paonias excæcatus* S. & A.; caterpillar.

ered with white. Its body is of an apple-green color, paler on the back but deeper along the sides. Its skin is roughened with numerous white-tipped granulations; the caudal horn

is bluish; seven oblique stripes, of a pale yellowish-white color, are found on each side of the worm, the last one of a brighter yellow than the others, and extending to the base of the horn (Fig. 52). The caterpillar enters the earth for pupation and changes to a chestnut-brown smooth pupa, with a short terminal spine.

The moth (Fig. 53, Plate VIII) appears from May to July, but chiefly in June. It is a very handsome insect. Its body is fawn-colored; on the top of the thorax is a chestnut-colored stripe, and on the abdomen a dark-brown line. The front-wings are fawn-colored, or rich brown, clouded and striped with two broad bands of lilac-gray; the hind-wings are rose-colored in the middle, with a brownish patch at the tips, crossed by two or three short whitish lines, and having near the inner angle a black spot with a pale blue center. The antennæ of the male are pectinated beneath. The moths measure with expanded wings about three inches across.

This and some other closely allied moths have very short, scarcely visible tongues, and their fore-wings are generally scalloped on the outer edge. When at rest, the anterior portion of the hind-wings projects beyond the front-wings, and the abdomen is usually turned upwards. In this position the highly-colored eye spots are no longer visible, and the insect resembles very closely a dead leaf.

This insect is by no means a rare one in Minnesota. Its larva is found on the apple tree and also on the plum and wild cherry, but it prefers the smaller oaks. It causes but little damage to our fruit trees. The caterpillars are not readily seen, as they assume during the day a rigid and sphinx-like position, but they make their presence readily visible by defoliating whole branches.

THE PURBLIND SPHINX.

(*Paonias myops* S. & A.).

This is another moth closely allied to the preceding one. It is somewhat smaller, measuring, when the wings are expanded, about two and a half inches across. It is very handsome, and much brighter than the *excæcatus* (Fig. 54, Plate VIII). It has a chocolate-brown head and thorax, with a purplish tinge; the thorax has a tawny-yellow stripe down the middle; the abdomen is brown, with dull yellowish spots. The fore-wings are chocolate-brown, with black bands and patches. The hind-wings are dull yellow, with the outer half chocolate-brown; an eye-like spot is found towards the inner margin; it is black with a large pale blue center. When at rest this moth is also thoroughly well protected by its position and color, which unite to give it the appearance of a dead leaf.

The caterpillar of this moth occurs on the cherry tree, but is uncommon. Since the electric lights have been introduced the moths are seen more frequently. The caterpillar is found during August; it is a large, cylindrical green worm, about two inches long, with a curved horn at the end of the body. Its head is bluish-green, with a bright yellow line on the sides; the body is green, with a row of reddish-brown spots on each side of the back, and another similar row down near the breathing pores. Along each side there are six oblique, bright yellow bands, and two short yellow lines on the anterior segments. The horn is green, tinted with yellow at the sides. When full grown the caterpillar enters the earth, where it changes to a dark brown pupa, which remains in the ground until the following June or July, when the perfect insect escapes.

The caterpillar is not common enough to cause great injury to cherry trees, and as it can be readily detected by its work it is easily kept in check.

THE COMMON DOUBLE-EYED SPHINX.

(*Smerinthus geminatus* Say).

This is one of the most common species of hawk-moths found in Minnesota. The caterpillars feed upon a variety of plants, such as the apple, plum, ash, willow, birch and others.

The mature caterpillar is about two and a fourth inches long, of an apple-green color, somewhat lighter above, with pale green or whitish granulations over the surface. Its head has a yellow stripe on each side, and there are seven oblique stripes on each side of the body, of a pale yellow color, except the last one, which is bright yellow. There is also a stripe on the side of the forward segments. The anal shield and plates are granulated and of a darker green than the rest of the upper surface, but of the same color as the under surface. The caudal horn is slightly curved, of a violet color and granulated (Fernald). It is not an uncommon occurrence to find some of these green worms marked with a series of bright red spots along their sides, as shown in Fig. 55, Plate XV.

The moth (Fig. 56, Plate VIII), which expands two and a half inches, has a pale gray head and thorax; in the middle of the latter is a rich, dark brown triangular spot, which is rounded in front and widened out behind. Both abdomen and under side of body are brownish-gray. The gray forewings have a rosy tint in some examples; the discal spot is whitish, bordered with dark brown, and a dark brown line, edged on the inside with white, starts from the basal third of the costa at right angles with it, and runs about half way across the wing, where it forms nearly a right angle, and then runs across to the hinder margin. The lower part of this line is wider, and shades off on the outer side. A broad, dark-brown, oblique stripe starts at this line and ends at a narrow, wavy, pale band, which crosses the outer

part of the wing; within it is a darker band with a still darker straight inner edge. Outside of the pale band are several indistinct lines crossing the wing, a dark brown spot just inside of the anal angle and a lunulate spot of the same color edged on the inside with white. The hind-wings are rosy red, with gray costal and outer borders. There is a large black spot with two blue spots on it near the anal angle, and connected with it by a narrow, black stripe. Occasionally a third blue spot appears, but sometimes there is but a single one.

The globose eggs are somewhat flattened, and of a pale green color.

THE WALNUT SPHINX.

(*Cressonia juglandis* S. & A.).

This is still another Sphinx closely related to the preceding species, but quite different from them, as it lacks the bright eye-like spot upon the hind-wings. The moth, which expands two and a half to three inches, is uniformly light brown or pale lilac-gray (Fig. 57, Plate VIII). The fore-wings are somewhat clouded with brown in the outer part and also through the middle. Near the outer margin are two fine parallel lines, about a tenth of an inch apart, that cross both the fore and hind-wings; near the body are two similar lines which cross only the fore-wings and enclose a square dark-brown spot adjacent to the middle of the inner margin. The females are much larger, and of a lighter brownish-gray color than the males, with the square spot on the fore-wings less distinct. The antennæ are pectinated beneath in the male.

The caterpillar is of a pale brownish-green color, with a long caudal horn. It has a small head, and the body is attenuated before and behind; there is a row of sub-dorsal and stigmatal reddish-brown spots, and seven oblique, lat-

eral, bright yellow bands. When disturbed it makes a creaking noise by rubbing together the joints of the forepart of the body. It enters the earth to transform into a pupa.

This insect is very uncommon in Minnesota, but has been found as far north as Duluth, though none of its food plants, viz., walnut and hickory, grow in that region, which indicates that its caterpillar must also be able to subsist upon other food. If ever it should become numerous in nurseries and wind-breaks, or wherever walnuts or hickories are grown, it can readily be kept in check.

FAMILY SESIIDÆ OR CLEAR-WINGED MOTHS.

There is, perhaps, no other family of moths so well separated from all other families as that of the Sesiidæ. They are all small, with slender bodies; they fly only by day, and frequently in the brightest sunshine. Their larvæ are borers; the caudal horn is absent, and in consequence of their mining habits their colors are uniformly yellowish-white, and only head and legs are darker. Many of the species of moths belonging here are very beautiful, and most of them are remarkable on account of the protective mimicry exhibited by them. This close resemblance to insects of different orders was observed long before the significance of protective mimicry was understood. The majority of the Sesiidæ mimic bees, wasps and flies. We all know from experience that bees and wasps can advance some very pointed arguments to be left alone, and any other insect that closely mimics such well armed warriors is very apt to be left unmolested. This mimicry is not simply a superficial one, since even their motions, if captured or disturbed, are like those of the insects imitated. Their attitude when resting, the sounds they produce, their hyaline wings, their ringed body, even the odor they give off, all are apt to warn us and

to caution us. Yet though they pretend to sting they lack the necessary organ for that purpose.

Their larvæ, being miners, are destructive to the shrubs and trees they infest. Some bore through solid wood; others prefer the pith of woody stems; others are found just under the bark, while still others enter the roots of plants.

THE NATIVE CURRANT-BORER.

(*Alcathoe caudatum* H. Edw.).

Although no specimens of this interesting species have been captured, their work has been noticed several times; the larvæ of it infest the wild species of currants.

THE RASPBERRY ROOT-BORER.

(*Bembecina marginata* Harr.).

This insect resembles a wasp, and most persons would not dare to touch it on that account. Its front-wings are transparent, veined with black or brownish, and heavily margined with reddish-brown. The hind-wings are also transparent, and fringed with dark-brown. The body is black, banded and marked with golden-yellow. The wings measure almost an inch if expanded. Fig. 58 shows both sexes of this insect. Like other clear-winged moths, the insect flies about during the hottest part of the day in early summer, and the females are also engaged at this time in depositing their eggs. The

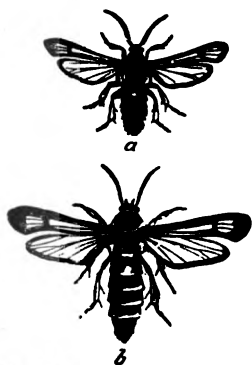


Fig. 58.—*Bembecina marginata* Harr.—a, male; b, female.

young larva enters the cane, inside of which it feeds upon the pith; it gradually works its way down to the root,

in which it passes the winter; here it eats extensive cavities. As soon as the warmer weather indicates the advent of spring the worm becomes active again and enters another cane, where it feeds for some time. When full grown the worm prepares an opening for exit, as the moth has no mouth to do so and would otherwise die a prisoner. At this time the larva measures about an inch and is of a yellowish-white color with a dark brown head and a few shining dots on each segment of the body. Near the place of exit the larva changes to a pupa and when the time arrives for the moth to escape the pupa wriggles itself forward by means of fine spines encircling the segments. Soon after the moth appears, leaving the empty shell of the pupa sticking out of the cane.

The canes infested by such worms invariably die. But little can be done to prevent the damage to our raspberry canes as the worms are so well hidden, and the only method we have to lessen the evil is to remove all old canes and all others that are not in a thrifty condition.

THE GRAPE-VINE ROOT-BORER.

(*Sciapteron polistiformis* Harr.).

This fine insect is much larger than the one just described, measuring with expanded wings fully an inch and a half across. It is very uncommon in Minnesota, and but a single specimen was seen in 1898 flying about the wild grape-vines on Gray Cloud Island. The moth resembles one of our large paper-wasps (*Polistes*), and on that account was named "Polistes-shaped." The sexes vary, the male having toothed antennæ, while those of the female are simple. The male has thorax and abdomen darker in color, and has also in addition to the short pencils of orange hairs on the lower side of the abdomen two longer ones above. There is a bright yellow band on the base of the second abdominal segment and usually another one on the fourth,

but this is sometimes wanting. The fore-wings are brownish-black, with a more or less distinct clear patch at the base; the hind-wings are transparent, with the veins, terminal border, and fringe, brownish-black.

The insect is much more common in the Southern States, where it is sometimes very destructive to the wild and cultivated grapes. It is said that the female moth deposits her eggs upon the collar of the vine, close to the earth. As soon as hatched the worm enters the cane and descends to the roots, where it consumes the bark and sap-wood, eating irregular furrows in their substance; sometimes it eats the bark, and at other times works its way into the roots. The mature larva is of a yellowish-white color, with darker

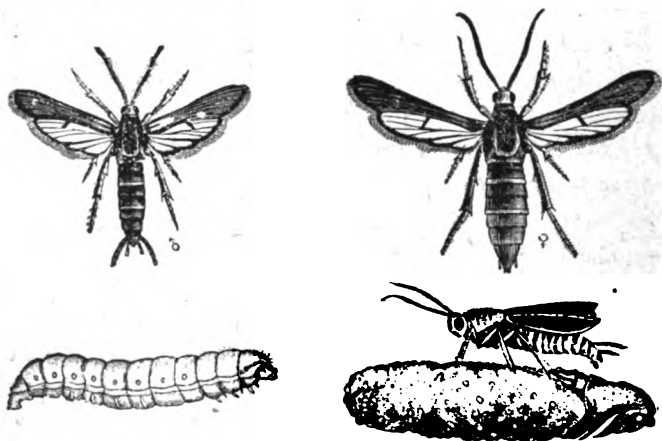


Fig. 59.—*Sciapteron polistiformis* Harr., larva, cocoon, male and female.

head and legs, and measures about an inch and a half in length. It now forms a pod-like cocoon of a gummy sort of silk, covered with little bits of wood, bark and earth, and situated within or adjacent to the injured root. In this cocoon the larva changes to a brown pupa which works itself out of it by means of minute teeth upon the margins of the segments, as soon as the moth within is ready to emerge. Fig. 59 shows the different states of this insect.

In several instances the roots of very small plum trees growing in a nursery were destroyed by a similar larva which had to live outside of these roots as these were quite small. Considerable damage was caused by the worms, but as none could be kept alive in confinement it is impossible to state to what species these destructive larvæ belonged. Infested roots are shown in Fig. 60, Plate IX.

THE PEACH-TREE BORER.

(*Sannina exitiosa* Say).

This is a notorious pest and very destructive to peach orchards. It is a pity that it is not found in our State, as its presence would indicate that we possessed a clime warm enough to successfully grow the succulent peach. Still some peach trees are grown and succeed in Minnesota, and with proper protection it is by no means impossible to grow this fruit. Perhaps the insect mentioned above as being injurious to the roots of plum-trees is this very species, as the peach-tree borer works also upon the plum. In fact, as this insect is a native one, it had in former times to feed upon something else than the peach-tree, as this comes from Persia.

The adult insects appear in the Northern States and Canada from about the middle of July to the end of August. The sexes differ very much. The female is much larger than the male, with a broad and heavy abdomen; her body is of a glossy, steel-blue color with a purplish reflection, and a broad band of orange-yellow crosses the abdomen. The fore-wings are opaque and similar to the color of the body; their tips and fringes have a purplish tint, both above and beneath. The hind-wings are transparent and broadly margined with steel-blue. The wings expand about an inch and a half across. The smaller male, measuring not more than

an inch, has also a steel-blue body with golden-yellow markings and a glossy, silken lustre. Its body is quite slender; the black antennæ are fringed on their inner side with numerous fine, short hairs, which are absent in the female. Head and thorax are marked with yellow, and the abdomen has two slender yellow bands above and a white line on each side of the tuft of hairs at its tip. The wings are transparent; the veins, margins and fringe, steel-blue, and a steel-blue band extends nearly across them beyond the middle. The feet and legs are marked with white. Both sexes are illustrated in Fig. 61.

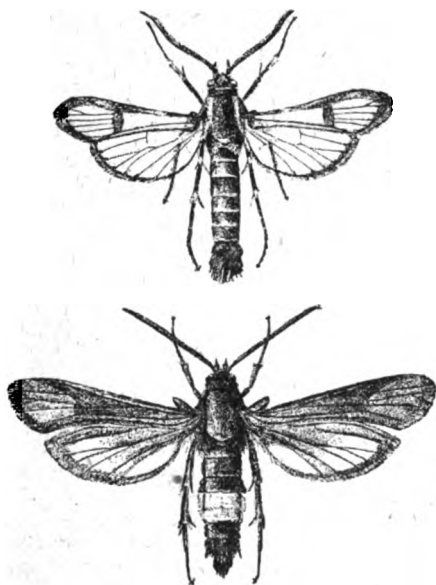


Fig. 61.—*Sannina cixtioides* Say. Male and female.

The female deposits her eggs on the bark of the tree at the surface of the ground. The yellowish eggs, with finely sculptured surfaces, are oval and slightly flattened, and are glued to the surface of the bark by a gummy secretion.

Prof. Saunders, in his excellent book: "Insects injurious to fruit," gives a number of remedies against this pest, and as we can learn some lessons from them, they are quoted:

"REMEDIES.—Several remedies have been proposed to meet this evil. Where the larvæ are present, they are readily detected in consequence of the exudation of gum; hence early in spring the trees should be carefully examined, a little of the earth removed from about the base, and, if masses of gum are found, the larvæ searched for and destroyed. Hot water

is said to be very effectual in killing them; it should be used very hot, and after the earth has been removed, so as to insure its reaching the culprits before it cools. Among the preventive measures, much has been written in favor of mounding the trees, banking the earth up around the trunk to the height of a foot or more, and pressing it firmly about the tree. Some allow the mounds to remain permanently; but the better plan seems to be to mound up late in the spring or toward midsummer, and level off the ground again in September, after egg-laying has ceased and the moths have disappeared. This treatment is said to make the bark very tender and liable to injury during the winter, and it is recommended by some to defer its application until the fourth year, by which time the bark will have become sufficiently thickened and hardy to endure the treatment without injury. Placing around the roots a bed of cinders, ashes, or lime, plastering the base of the trunk with mortar or clay and covering it with stout paper, coating the tree with an application of soap or tobacco water, have all had their advocates; but the weight of testimony is in favor of the removal of the larvæ with the knife late in the autumn or early in the spring, and subsequently mounding the trees in the manner already described.

"Another remedy proposed is to cover the trunk with straw in the following manner: Scrape the earth away from the collar, place a handful of straight straw erect around the trunk, fastening it with twine, then return the soil, which will keep the ends of the straw in their place. The straw should entirely cover the bark, and the twine be loosened as the trunk increases in size. Trees so protected are said to have remained uninjured while all around them have suffered from the borer."

THE CURRANT BORER.

(*Sesia tipuliformis* Linn.).

This insect was described and illustrated in the first annual report of the entomologist, but to have all the descriptions of lepidopterous insects injurious to our fruit trees together in one volume, it is repeated.

The currants in all their varieties, as well as the different kinds of gooseberries, have no greater enemy than the above borer. The damage it causes is so much greater than that inflicted by other enemies of these plants, because a whole cane, even a whole plant, may be killed by a single borer, nor can its work be noticed until the injury has been done. Like so many of our destructive insects it was introduced from Europe with the plants that it destroys, but it is now more injurious here than in its original home. The insect is illustrated in Fig. 62, Plate IX, where its work, the larva, empty pupa and adult are shown. A glance at the latter shows that it is a beautiful moth. When seen in June upon the bright foliage of currants, it is indeed an elegant insect, in whatever position it may be observed. It shows to the greatest advantage, however, when making love to its mate. In this case the male dances about very gracefully, rapidly opening the fan-like feathers at the end of the abdomen; and as the whole insect is clothed in glossy scales it reflects all the prismatic colors. The adult insect, as seen in the illustration, is quite different from ordinary moths, having its wings but partly covered with scales, the uncolored parts being glassy, hence the reason why such moths are frequently called "glassy wings." Such moths resemble flies and wasps, and are frequently mistaken for such; in fact they sometimes mimic such stinging insects so effectually that even a well trained entomologist has some scruples about capturing them with his hand. Some of these moths carry this resemblance so far as to even threaten to sting,

though not possessing an organ to execute the threat. This currant-borer does not possess a tapering body and its posterior end is ornamented with a fan-like covering of scales. The wings have black markings with purplish reflections; the body is ringed with yellow, the thorax is also ornamented with yellow lines. The female, though resembling the male very closely, is not so active; she has other and more serious business on hand than dancing, since she has to deposit her numerous and rapidly developing eggs. For this purpose she selects canes at least one year old. The beautiful egg, possessing the usual form of eggs of lepidopterous borers, is fastened most frequently in the angle made by the leaf and the cane. Other eggs are laid below the loose scales found upon the canes and in the cracks of bark. These eggs soon hatch, and the young caterpillar or borer eats its way into the interior of the cane, penetrating to its very pith. Here, apparently well protected against all enemies, the caterpillar has a congenial home surrounded with plenty of food, and soon a long tunnel, sometimes several feet in length, shows that the appetite of this recluse does not suffer by its isolation. We never find more than one caterpillar in each burrow, showing that the females have been very careful in exploring the cane before entrusting it with an egg. The caterpillars grow but slowly, and at the approach of winter are not much more than half grown. They now prepare for the cold season by retiring as deeply in their tunnels as these will permit, and surrounded by frass and chewed up fibres of the pith and wood, they are well protected.

The larva possesses the usual form of caterpillars of this family of moths. It is of a yellowish color, with a brown head, as shown in the illustration which also shows the piliferous spots and hairs.

When the warmth of the sun in spring starts vegetation, and soon after the flowers of the currants open, the hibernating larva also feels imbued with new life and energy, and

rapidly grows to its full size, being after the long enforced fast much more voracious than during the previous season. This great appetite is soon felt by the plants; many canes with flowers and partly expanded foliage show by their small leaves and their yellowish appearance that they are suffering from the insidious enemy in their interior. Most of the canes attacked soon die, or are broken down by the first wind or heavy rain. The larger ones may remain alive for another year; but are certain to die later, as a hole through which the winged borer has issued permits the entrance of rain and this moisture, in combination with parasitic or other fungi, soon starts decay, as may be seen by the black interior of such tunnels.

The larva, when full grown, prepares for pupation by first eating a hole through the cane so, as to permit the future moth to escape. If this were not done the moth, which has no mouth, or at least only a rudimentary one and which is consequently unable to eat its way out of the cane, could not leave at all. After providing for such an exit, this hole is slightly closed from within with bits of wood, and the larva changes to a chrysalis or pupa, as is shown in the illustration.

The pupa is of a light brown color. In the illustration an empty one is shown projecting from the hole or exit prepared by the caterpillar. The peculiar spines enabling it to move are also shown. The two long processes seen in the illustration are simply the sheaths in which the long antennæ were hidden; before the moth issued, these were soldered to the sides of the pupa and were not more prominent than the encased wings and legs.

Towards the end of May or during June, according to the climatic conditions prevailing at the time, the pupa forces its way partly out of the tunnel of the cane and pushes away the plug closing the exit. This movement is made possible by the rows of spines found upon the abdominal segments. The pupa is now partly outside of the cane

and is held in position by its posterior portion. It now splits open in the usual manner upon its back and the winged moth appears.

To this account of the life-history of this injurious borer may be added that no parasites have as yet been discovered in Minnesota. Yet several times a silken cocoon was found in a tunnel which, apparently, had been recently inhabited by a borer. The small wasp issuing from this cocoon is distinguished by blackish wings, black body, and bright red abdomen; it is a species of *Bracon*. In some cases mites were found upon the dead caterpillars inside the burrow, but whether these had killed the caterpillar, or had simply come to feast upon its dead body, is impossible to say, though most likely the former was the case.

REMEDIES.—An insect so well hidden as this borer can not be reached by any poison; and our only hope is to prevent it from entering at all. This seems to be very feasible, as the egg is deposited upon the cane or pushed beneath loose bark, which is frequently the case with borers belonging to the order of beetles. When the young currant-borer leaves the egg it has to come in contact with the bark through which it has to eat its way. If, therefore, the bark could be poisoned, we should have a sure remedy; but when it comes to a practical application of this spraying, it will be found that currant bushes are rather difficult to spray so thoroughly as to coat the canes in a uniform manner with the poison. The writer has tried repeatedly to coat the canes with arsenical poisons before the foliage had appeared. There was no difficulty in doing so, but it was found later that the plants sprayed in this manner contained just as many borers as those not sprayed. This is owing to the fact that at the period when this spraying can be done, we usually have the most frequent rains. There is, however, another remedy which is easily applied and which, if carefully carried out, will eradicate this insect from our gardens. Canes that harbor the borer can always be detected and if

found should be pruned below the lowest part of the tunnel. The canes that have been cut off should be taken away from the garden and burned as soon as dry, or if such pruning is done late in the spring the canes should be covered up with soil, so as to prevent the moths from leaving. In no case should they be left on the ground, because cutting them off from the plant does not kill the borer. The pruning is also otherwise of benefit to the currants which are usually permitted to grow too much wood and become too old for the benefit of good crops of berries.

Some varieties of currants and gooseberries are stated to be free from borers. If such is the case the writer has not seen them. It has also been claimed that black currants are not to the taste of such borers, but those under observation not only did not escape the ravages of this pest, but were even preferred to the red and white currants that grew in their immediate vicinity.

ROOT AND STEM BORER OF BLACKBERRY AND RASPBERRY.

(*Sesia hemizonæ* H. Edw.).

It is doubtful whether this insect occurs in Minnesota, although a broken specimen of it was received from a nursery. The larva is a pale worm with darker head and legs, and feeds in the roots or base of the canes of the cultivated blackberry and raspberry, invariably killing the canes infested, or the entire plant. The worms feed only on the pith, and thus cause a wilting of the cane. The canes infested should be cut out and burned. The moth possesses golden-brown fore-wings, and as all the borders are wide, only a small transparent space is left; the discal mark is purple-black, orange behind, with golden reflections; hind-wings with golden margins; fringes of both wings golden-brown; head black, with a few shining blue scales in front; thorax with collar, tegulæ and base lemon-yellow; abdomen

ringed with lemon-yellow; caudal tuft deep lemon-yellow, with a black centre; palpi, fore-coxæ and tibiæ lemon-yellow, the latter banded with brown.

Neglected plants, or plants infested with other insects or diseases, are more apt to harbor this and allied borers than plants which receive the proper attention.

THE PLUM TREE BORER.

(*Sesia pictipes* G. & R.).

This insect is by no means uncommon, and seems to be increasing in numbers as our plum trees grow older and be-

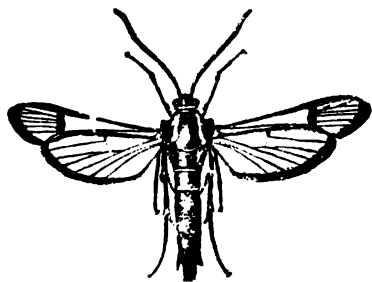


Fig. 63.—*Sesia pictipes* G. & R. Male.

come more numerous. The sexes of *pictipes* are similar and so closely resemble the male *exitiosa* that one may be readily mistaken for the other. The male is shown in Fig. 63.

The larva of this borer feeds mainly in the trunks and branches of both cultivated and wild plums and in wild black and red cherries. The pruning knife is the best remedy we have against this insect.

FAMILY AGARISTIDÆ OR WOOD-NYMPH MOTHS.

The moths belonging to this family are mostly beautiful insects, being either black, with large, white, yellow or red spots and patches upon their wings, or they have their front-wings white, margined with brown, and the hind-wings pale yellow. But few species are found, which fly chiefly during the day, but some of them are also attracted to the electric light.

We have in Minnesota a number of such moths, which are decidedly destructive in their early stages to our grape-vines, much more so than most other kinds of insects. In some years nearly the entire foliage of cultivated and wild grapes and of the Virginia creepers is devoured by them in the course of a few days.

THE EIGHT-SPOTTED FORESTER.

(*Alypia octomaculata* Hbn.).

This is a most beautiful moth, which flies about in the bright sunlight, displaying its brilliant colors upon the leaves of grape-vines which contrast strongly with the black, white, red and yellow colors of the moth. It never hides, but always displays its colors. This is evidently done as a protection, as these colors are warning colors, which tell birds and other lovers of insects as food that the moth showing them is not good to eat. The ground-color of this fine moth is a deep blue-black; two large pale-yellow spots are found on each of the front-wings, and two white spots on each of the hind-wings, the one nearer the base being much the largest. The shoulder-covers are yellow, and the legs partly orange. The sexes differ somewhat, the male having proportionately larger and more conspicuous spots, and possesses also a white mark along the tip of the abdomen. The wings, when expanded, measure from an inch to an inch and a half across.

The caterpillar is of a light brownish color, with many black lines and an orange band across each segment. It is distinguished from other similar larvæ by having eight black and white lines on each segment. The caterpillars have a peculiar bluish appearance which is owing to the blending of the two colors. The head and the shield on the first segment are a shiny, bright, deep-orange color, marked with black dots; there is a prominent transverse orange-red band, faint on segments two and three, conspicuous on four and eleven, and uniform in the middle of each of the

other segments. In the middle segments of the body each orange band contains eight black conical elevated tubercles, from each of which grows a white hair. A lateral white wavy band, obsolete on the thoracic segments, but very conspicuous on the tenth and eleventh, is a very characteristic feature of this caterpillar. The very young worms are whitish, with brown transverse lines; they feed beneath the leaves, and can let themselves down by a silken thread; the full grown larvæ also often conceal themselves within a folded leaf. The larva becomes nearly an inch and a half in length; when full grown it bores into any soft, rotten, or even almost sound wood, and if such material should be lacking it transforms to a pupa within a very slight cocoon formed without silk upon or just below the surface of the earth. With us this species is single brooded and passes the winter in the pupal stage.

This insect occurs frequently in such numbers upon the beautiful Virginia creepers adorning verandas that not a

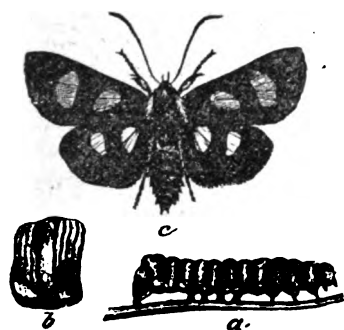


Fig. 66.—*Alypia octomaculata* Hbn.;
a, caterpillar; b, one segment of the
same c, adult. After Riley.

leaf is left, and the plant becomes just the opposite from what it was intended to be. This happens frequently in our larger cities, and of course should not be the case. As the caterpillars feed more or less exposed they can easily be seen and destroyed by the use of Paris-green or London-purple. If people object to the use of these poisons they

should use a spray composed of two ounces of pyrethrum to a gallon of water. If used as long as the caterpillars are still young all injuries to the ornamental plants and the grape-vines can be prevented.

This beautiful moth is illustrated in Figs. 64, 65 and 70 on Plates X and XI, and also in Fig. 66.

THE GRAPE-VINE EPIMENIS.

(*Psychomorpha epimenis* Drury).

There is another bluish caterpillar found feeding upon the foliage of the grape-vine, but it is very uncommon in our State. It is much smaller than the one described above. It transforms into a most strikingly marked moth, of a deep, velvety-black color, with a broad irregularly lunate white patch across the outer third of the front wings, and a somewhat larger more regular patch of orange-red or brick-red on the hind-wings. The under side is similarly marked, but that of the front-wings is less velvety, with two additional white spots inside near the costa, the outer one generally,

and sometimes both of them, connected with a broad white patch. The surface of the wings is sprinkled with brilliant purple scales, which form a narrow band near the outer margin of each, and appear more or less distinctly on the basal half of the front-wings.

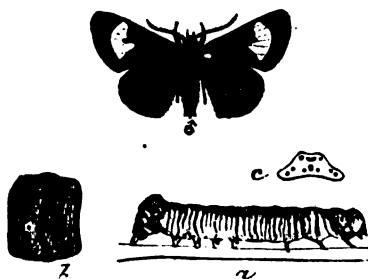


Fig. 67.—*Psychomorpha epimenis* Drury:
a, larva; b, one segment of the same;
and male moth. After Riley.

The antennæ of the female are thread-like, with alternate black and white scales; those of the male are broadly toothed on two sides. The moth is shown in Fig. 67; also in Fig. 70, Plate X.

The young larva attacks the terminal buds of the vine in spring, and by fastening the young leaves together by a few silken threads it forms a little enclosure. Early in June, when it is full grown, it bores into soft wood or any other suitable material, and there changes to a reddish-brown pupa, about four-tenths of an inch long, roughened on the joints, and having a curious flattened horny projection on each side of the tip. The insect winters over in the pupal state.

THE BEAUTIFUL WOOD-NYMPH.

(*Eudryas grata* Fab.).

The larva of this beautiful moth is almost as destructive to the foliage of the grape as the Eight-spotted Forester, but it is not found in such destructive numbers year after year as the latter insect. The moth has milk-white front-wings, broadly bordered and marked with brownish-purple. The band on the outer margin is shaded on the inner side with olive-green and marked towards the edge with a slender, wavy white line. The brownish-purple band is continued along the hinder edges, but gradually becomes narrower, and terminates near the base. There are two brownish spots near the middle of the front-wing, one round, the other kidney-shaped; they are frequently so densely covered with white scales as to be indistinct above, but they are always visible on the under surface. The under surface of the wings is reddish-yellow. The head is black, and there is a wide black stripe down the back, merging into a series of black spots extending to near the tip of the abdomen, which is tufted with white. The shoulder-covers are white, and the sides of the body deep yellow, with a row of black dots along each side close to the under surface.

The moth, which is active at night, and sometimes attracted to the electric lights in large numbers, is often discovered during the day upon the surface of the leaves of its food-plants. (See Fig. 65, Plate X). Its closed wings form a steep roof over its back, and its forelegs, which have a curious muff-like tuft of white hairs, are protruded and give the insect a very peculiar appearance. Looking at it from a short distance the insect resembles very closely the fresh and still semi-fluid droppings of a bird. The moth evidently depends upon this resemblance, which is sometimes unpleasantly realistic, as a protection against birds.

There are hardly two moths more unlike in general appearance than the beautiful Wood-nymph and the Eight-

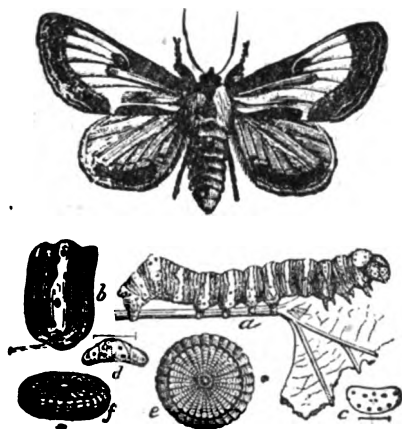


Fig. 68.—*Eudryas grata* Fab.; a, larva; b, one segment of same; c and d, eggs, greatly enlarged; and adult. After Riley.

spotted Forester, and yet their caterpillars bear such a close resemblance to each other that they are not readily distinguished from each other, especially as they frequently feed side by side upon the same grape-vine. Generally however, the caterpillar of *grata* appears a little later in the season. It is shown in Fig. 68, Plate XII.

The eggs are deposited upon the under side of the leaf, singly or in groups. The full grown caterpillars measure about an inch and a half in length; their bodies taper towards the head, becoming thicker near the posterior end. The head of the caterpillar is dull orange, with black dots; the body is pale bluish, crossed by orange and black lines which are arranged as shown in the illustration, Fig. 69. Each segment, with the exception of the head and the last one, is crossed by a brick or orange-colored band of uniform width, excepting the one on the twelfth segment, which is broader; on the last segment we find two such bands. All these bands contain black dots, from which a simple short brown hair arises. Each segment is crossed by six black lines; the breathing-pores are oval and black. Besides the grape-vine the caterpillars feed also upon the Virginia creeper, and occasionally upon the hop. They are most numerous late in summer, and do not web together leaves for shelter, but hide on their under side. When at rest, the caterpillar depresses the head and raises the anterior

part of the body, and in this manner assumes the position of a Sphinx caterpillar.

When mature the caterpillar descends to the ground, and transforms to a dark-brown and rough pupa, about seven-tenths of an inch long, with an obtusely conical tip of the abdomen, ending in four tubercles. In captivity it readily enters pieces of soft wood, or of cork, in which it forms a cell for the purpose of pupation; by uniting with a sticky secretion bits of wood and cork it forms a cap or lid over the cell.

Like the Eight-spotted Forester this insect is kept in check by parasites, but chiefly by *Tachina* flies, which deposit their cream-white eggs upon the back of the caterpillar, usually close behind its head.

THE PEARL WOOD-NYMPH.

(*Eudryas unio* Hub.).

The moth (Fig. 69 and 70, Plate X) of this equally pretty insect is a little smaller than *grata*, measuring with expanded wings about one inch and three-eighths; it differs but slightly from its larger relative. The brownish-purple stripe on the front margin extends farther along the wing; the bordering of the outer margin is paler and more uniform in width; the inner edge is wavy instead of straight, and the bordering of the hind margin is wider and more distinct.



Fig. 69.—*Eudryas unio* Hub.;
Adult. After Riley.

The larva is nearly an inch and a quarter long. It has an orange-colored head, spotted with black; its body is banded with orange, white and black, most segments having three white and three black lines on each side of the central orange band. The pupa is reddish-brown, roughened on the back with very minute teeth; a thick and blunt spine occurs on each side of the tip of the abdomen.

This insect is not seen very often on our grape-vines, but as this moth has been frequently seen near the electric light it must be rather common. The caterpillars are not so particular about their food as the other closely allied species and they have also been found feeding upon such plants as *Epilobium* and *Hibiscus*.

The four species of Wood-Nymphs are also shown in Fig. 70, Plate X.

FAMILY PYROMORPHIDÆ OR SMOKY MOTHS.

But few moths belonging to this family are found in the United States. The moths are small, chiefly of a smoky-black color, although some are marked with brighter colors.

THE AMERICAN PROCRI.

(*Harrisima americana* Harr.).

The writer has never found in Minnesota the caterpillars of this insect, which is quite destructive to the foliage of the grape-vine in other states, but as he has repeatedly captured the moths there is no doubt that the insect is an inhabitant of our state.

The eggs, twenty or more of which were deposited together, are fastened to the under side of the leaves.

The caterpillars of the Procris do not scatter after leaving the eggs, as all the insects described before, but lead a social life, feeding side by side on the under side of a leaf, their heads all directed towards the margin of the same. These little worms, in black and yellow uniforms, eat at first only the soft tissues of the foliage, leaving the fine net-work of veins untouched; but as they grow older and stronger all but the large veins are eaten. The caterpillars reach their full size in August, and measure now about six-tenths of an inch. They are at that age of a yellow color, slightly hairy, with a transverse row of rather large spots on each seg-

ment. As soon as the caterpillars are mature they disperse, each one searching for and retiring to some sheltered spot, in which they construct a tough and oblong-oval cocoon, inside of which they change in the course of three or four days to a shining brown pupa, about three-tenths of an inch long. Further south two or even three generations are produced during a year, but whether the insect is single or double brooded in Minnesota is not known.

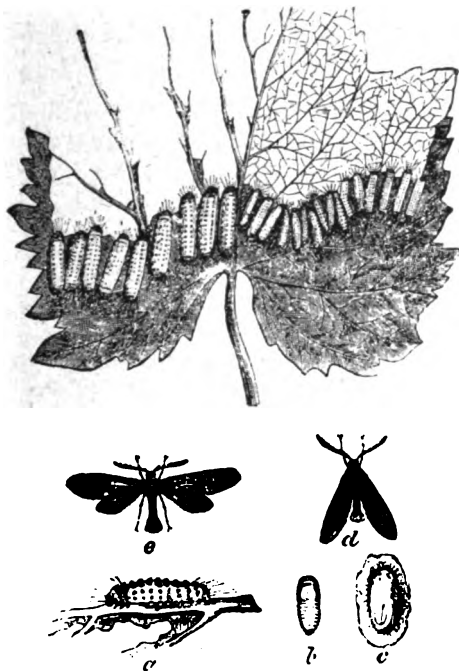


Fig. 71 —*Harrisima americana* Harr.; a, caterpillar; b, pupa; c, cocoon; d and e, moths; above, a colony of caterpillars. After Riley.

The little moth is of a bluish or greenish-black color; it is ornamented with a deep orange-colored collar, and a notched tuft at the end of the long body. The moth has very narrow wings, which expand nearly an inch across, and flies during the warmest hours of the day, when it frequents flowers. Its flight is rather peculiar, and is quite

slow and unsteady. Wherever this insect occurs in large numbers it becomes quite injurious, but as it leads a social life in its caterpillar-state it can readily be destroyed by the use of arsenical poisons. Fig. 71 shows the different states of this insect; the moth is also shown in Fig. 72, Plate IX.

FAMILY ZYGÆNIDÆ OR ZYGÆNIDS.

But few species of these moths occur in the United States, and none are destructive to fruit trees. They are distinguished from the allied families by the structure of the hind-wings, which are in some cases greatly reduced in size, as shown in the illustration of the *Scepsis fulvicollis* Hbn. (Fig. 72, Plate IX), a black moth with fulvous color, frequently seen on the flowers of the golden-rods. A larger species, the *Ctenucha virginica* Charp. is shown on the same Plate in Fig. 72.

FAMILY LITHOSIDÆ OR FOOTMAN MOTHS.

This family includes small moths with rather slender bodies, filiform antennæ, and usually narrow fore-wings and broad hind-wings. They are closely allied to the next family. Usually they are of sombre colors, though some are rather highly colored. Their larvæ are cylindrical, covered with short and stiff hairs, and most of them feed upon lichens. None are destructive, but to give an idea of their general appearance one of the most common species, the Striped Footman (*Hypoprepia fucosa* Hbn.) is shown in Fig. 72 on Plate IX. It is of a deep scarlet color, with three broad and lead-colored stripes on the fore-wings not shown in the photograph.

FAMILY ARCTIDÆ OR WOOLY BEARS.

The Arctiids, also called Wooly Bears and Tiger-moths, are stout-bodied moths, with moderately broad wings, which are usually spotted or striped. Some of them are

very gaily colored, others are pure white. When at rest they usually fold their wings roof-like upon the body. Most of them are nocturnal and are attracted to lights. Their larvæ are mostly clothed with dense clusters of hairs, and are usually very general feeders, preferring herbaceous plants, though some are destructive to the foliage of trees.

THE BLUE-SPANGLED CATERPILLARS.

(*Callimorpha Lecontei* Boisds. and *tulvicosta* Clem.).

There are some slender bodied Arctiids that possess fine or bristle-like antennæ, which are not distinctly feathered in either sex; their tongues are also quite long. They belong to the genus *Callimorpha* (meaning beautiful form). In the Eastern and Southern States these caterpillars occur more commonly upon the peach; here in Minnesota they have been found upon the apple, but chiefly upon the blackberries. They are black worms, covered with short stiff hairs, and studded with peculiar blue spots, which have given them the above name. They spend the winter in some sheltered spots, as under loose bark, etc., but as soon as the leaves expand in spring, they forsake these shelters and commence to feed. As they grow rapidly they soon reach their full size, and now measure about one inch in length. They are of a velvety-black color above, and pale bluish, speckled with black, below. A deep orange line extends along the back, and a still more distinct wavy or broken one along each side. The body is covered with many steel-blue warts, with a polished and quite brilliant surface; from each issues a short and bristly hair. As soon as full grown the caterpillar selects a sheltered spot, and here spins a slight and white silken cocoon. The pupa is purplish-brown, finely punctated, and terminates in a flat plate tipped with yellowish-brown and curled bristles.

The moth flies during the day in June. It is by no means very uncommon, and delights to fly about the edges of forests, or wherever the ground is overgrown with blackberries and similar plants. We have at least two species of this interesting moth; the *Lecontei* var *militaris* Harr., having the fore-wings ornamented with broad black markings, and the *fulvicosta* Clem., where the cream-colored fore-wings

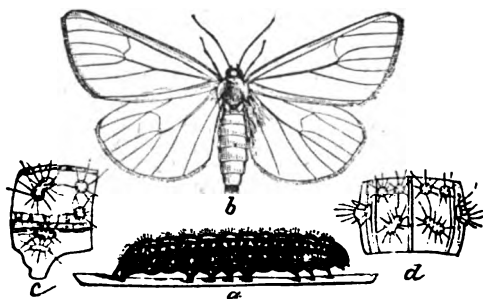


Fig. 73.—*Callimorpha fulvicosta* Clem.; a, caterpillar; b, moth; c and d, segments of body of larva. After Riley.

possess a fulvous border. Yellow markings are also found on the head, collar, and base and tip of the abdomen. Fig. 73 shows the larva and adult; Fig. 74, Plate XII, shows the same insect and also two forms of *C. contigua* Walk.

These caterpillars have been known to cause considerable damage to the young foliage of the peach tree and to the young leaves of the blackberries. They are easily shaken into sheets, and even into inverted umbrellas, because they drop to the ground as soon as the plants upon which they are feeding are jarred. In extreme cases the arsenical poisons should be used.

A number of other Arctiids or "Wooly Bears" are injurious to cultivated fruit trees and our smaller fruits. Generally, however, their caterpillars consume all kinds of low-growing plants and only exceptionally prove destructive to taller shrubs and trees.

THE ISABELLA TIGER-MOTH.

(Pyrrharctia isabella S. & A.).

This is the well-known caterpillar frequently called the "Hedge-Hog," from the habit of rolling itself into a ball when alarmed (Fig. 75). It has a thick coat of fur, composed of stiff hairs, which point in all directions. The hairs are black on each end of the body of the caterpillar, but reddish on the middle. As all the hairs are pretty evenly and closely shorn they give the caterpillar a velvety appearance,

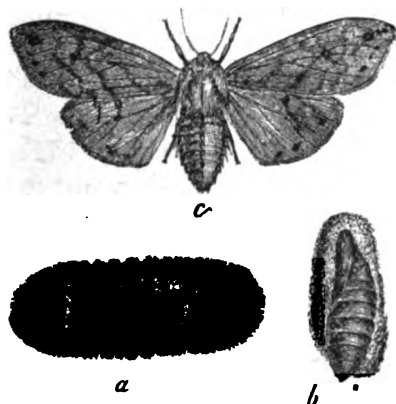


Fig. 75.—*Pyrrharctia isabella* S. & A.; a, caterpillar; b, pupa in cocoon; c, moth. After Riley.

and as they are also very elastic, it is not easy to pick up the curled larva, which generally manages to slip away. Its favorite food is plantain, clover, dandelions, grasses and many other plants. It winters over in some sheltered spot, rolled up like a hedge-hog. In most cases it finds shelter below loose bark, under pieces of bark resting on the ground, and is found in large numbers under wooden sidewalks. It is difficult to understand that an insect thus slightly protected should be able to withstand some of our very cold winters, and that the fluids found in its body are not frozen solid. Early in the spring the caterpillar makes up for the long

enforced rest, and feeding upon the first green vegetation, finally spins a cocoon, which is principally composed of the barbed hairs of the caterpillar itself, interwoven with coarse silk. The pupa is brown, with tufts of golden bristles, and with a tuft at the extremity. Prof. Comstock makes the following interesting remarks about this insect in his "Manual for the Study of Insects": 'Hurrying along like a caterpillar in the fall' is a common saying among country people in New England, and probably had its origin in observations made upon the larva of the *Isabella Tiger-moth*. This is the evenly clipped, furry caterpillar, reddish-brown in the middle and black at either end, which is seen so commonly in the autumn or early spring. Its evident haste to get somewhere, in the autumn, is almost painful to witness. A nervous anxiety is apparent in every undulating movement of its body; and frequently its shining black head is raised high in the air, and moved from side to side, while it gets its bearings. Occasionally after such an observation it evidently finds it is mistaken, and turns sharply and hastens along faster than ever in another direction."

The moth, which is also shown in Fig. 76, Plate XI, is of a dull orange color, with the front-wings variegated with dusky, and spotted with black. The hind-wings are lighter colored, and also marked with black spots; they vary somewhat in the sexes. The body has also the same general color of the wings; on the middle of the back of the abdomen is a row of about six black dots, and on each side of the body occurs a similar row of dots.

This caterpillar becomes sometimes destructive to the cuttings of apple-trees, etc., in our nurseries; blackberry and raspberry canes are also sometimes destroyed, as the larvæ eat the tips of the young shoots. They are readily poisoned and thus kept in check.

These "Hedge-Hog" caterpillars, although always common, are sometimes exceedingly so, while at other times but

few can be found. Their absence in the usual numbers is caused by the fact that very many of them are killed by a disease. Caterpillars attacked by the *Muscardine* are stiffly fastened to their food-plants, and are covered with a white efflorescence; this latter is not very apparent at the base of the dense hairs, hence such diseased or dead caterpillars look for a long time quite life-like.

THE LARGE YELLOW BEAR.

(*Leucarctia acræa* Drury).

These large and wooly caterpillars are sometimes quite numerous in our gardens and orchards. Usually they feed upon grasses and other low growing plants, but they are not slow to eat also the leaves of young fruit trees and of the small fruit. Both sexes of the moth are shown in Fig. 77, Plate XI.

THE COMMON YELLOW BEAR.

(*Spilosoma virginica* Fab.).

This is one of our most common hairy caterpillars, and whoever has a garden must have met with this troublesome insect, which devours alike flowers, vegetables and fruit. With us it seems to be very partial to the leaves of the grape-vine, apple, currant and gooseberry, though nearly all other plants are eaten when pressed by hunger, and the insect is sometimes very destructive to corn, beans and peas. It is found from June to late in September. When young the caterpillars are bluish-white, but when full grown they may be found of a pale cream color, yellow, light-brown or very dark-brown, the different colors often appearing in a brood hatched from one batch of eggs. Yellow is, however, the most common color, and in all the different color-varieties the under side is dark, with a longitudinal black line, more

or less interrupted, along each side of the body, and a transverse line of the same color between each of the joints. Head and feet are ochre-yellow; the hairs spring from dark yellow warts, of which there are ten on each joint; those on joint one being scarcely visible, and those on joint twelve coalescing. We have two annual broods in Minnesota, the last passing the winter in the pupal state. The pupa is protected by a slight cocoon, made almost entirely of the caterpillar's hair; these are chiefly held or felted together by the interlocking of their minute barbs, and the whole is strengthened by a few silken threads.

The bright-colored eggs, which are round and yellow, are deposited on the under side of leaves in large clusters, and hatch into small hairy caterpillars, which feed together for a short time, but gradually scatter. As long as young they devour only the under side of the leaf, but the corresponding upper surface of it soon turns yellow and withers.

The moth, which is very generally called "The Miller," frequently flies into our rooms at night. It is easily recognized by its pure white color, by having the abdomen orange-colored above, with three rows of black spots; the wings possess also a few black dots, varying in number, there being usually two on each side of the fore and three on each of the hind-wings, though sometimes all the wings are almost immaculate, except one spot on the disk of the fore-wings. The antennæ are white above, dark brown below; head and thorax are white.

The best time to destroy these troublesome caterpillars is soon after they hatch, and when they are still feeding side by side. By making the worms drop into a vessel containing some kerosene oil, we can kill them quickly, and as they curl up and drop when touched even very lightly the work is rapidly performed. Of course if they are very numerous we have to use one of the arsenical poisons.

It is very fortunate that this species is subject to the attack of a number of parasites, which kill immense num-

bers of them. Without the assistance of these beneficial insects the caterpillars would multiply to such a degree as to be soon beyond our control. This species is illustrated in Fig. 78.

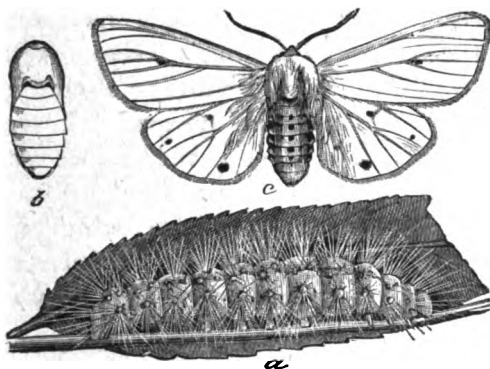


Fig. 78.—*Spilosoma virginica* Fab.: a, caterpillar; b, pupa; c, adult. After Riley.

THE FALL WEB-WORM.

(*Hyphantria cunea* Drury).

This is getting to be a very destructive insect in Minnesota, which at present seems to be confined to plum-trees. Both the wild and cultivated varieties are infested, and toward the middle of August they are disfigured by large nests made by colonies of these caterpillars. When we investigate these bulky nests, which show no regularity of construction like those of the tent-caterpillars, we find them composed of numerous smaller nests, of which the older ones are more or less filled with excrement, old skins, and the white head-plates of the caterpillars. Sometimes we find in them also the egg-shaped cocoons of hymenopterous parasites. The caterpillars are not as social in their habits as those of the tent-caterpillars, and they do not come and go to their nest in regular armies, but rather protect themselves when feeding by simply building a shelter over their food. Fig. 79, on Plate XXII, shows one of these nests.

The moths of this species of insects vary greatly, both in size and markings, and they have in consequence of such variation received many scientific names, such as *cunea*, *textor*, *punctata* and *punctatissima*, but there is no doubt that all these names belong to one species, as has been proven by the frequent breeding of these insects in confinement. The moth is of a milk-white color, and in Minnesota without spots. The antennæ are gray; those of the male, doubly feathered below, those of the females with two rows of minute teeth only. The front thighs are tawny-yellow; the feet blackish-brown. When the wings are expanded they measure about one and a quarter inches across. Fig. 80 shows the variations of markings in the wings.

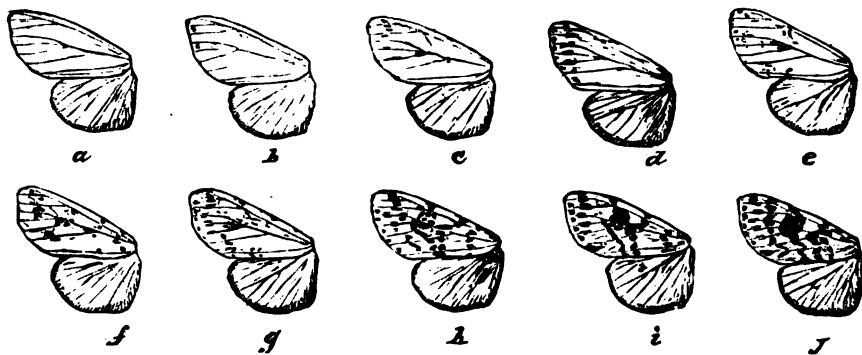


Fig. 80.—*Hyphantria cunea* Drury; ten variations in the markings of wings. From Div. of Entomology, Dep. of Agriculture.

The moths, which are only active at night, deposit their eggs in a cluster on a leaf, sometimes upon the upper, sometimes on the lower side, usually near the end of a branch

(Fig. 81). Each cluster consists of a great number of eggs, which are deposited close together and in regular rows whenever the surface selected permits this.

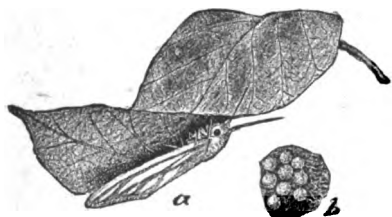


Fig. 81.—*Hyphantria cunea* Drury; a, moth depositing eggs; b, eggs. From Div. of Entomology, Dep. of Agriculture.

On an average each cluster consists of over four hun-

ered eggs. As the female deposits also eggs in smaller and less regular patches, we may say that five hundred eggs can be considered the real number produced by a single female. The eggs, measuring 0.4 mm., are of a bright golden-yellow color, quite globular, and ornamented by numerous regular pits, which give them under a magnifying lens the appearance of a beautiful golden thimble. Before the eggs hatch they change to a dull leaden hue. In the course of about ten days in cool weather, but much sooner when warm, these eggs hatch. Without check the offspring of one female moth might in a single season number 125,000 caterpillars in early autumn, enough to ruin the shade trees of many a fine street. This is reported from the fifth report U. S. Entomological Commission, but holds good only in regions where the insect is double brooded. Here, apparently, only one annual generation is found.

The caterpillars just born are pale yellow, with two rows of black marks along the body, a black head and with quite sparse hairs. When full grown they generally appear pale-yellowish or greenish, with a broad, dusky stripe along the sides; they are covered with whitish hairs, which spring from black and orange-yellow warts. The caterpillar is, however, very variable, both as to depth of coloring and as to markings, as is shown in Fig. 81.

Close observations have failed to show that different food produces changes in the coloration; in fact nearly all the various color varieties may be found upon the same tree. The fall generation is, however, on the whole, darker, with browner hairs than the spring generation.

As soon as the young caterpillars hatch they immediately go to work to spin a small silken web for themselves, which by their united efforts soon grows large enough to be noticed upon the trees. Under this protecting shelter they feed in company, at first devouring only the green upper portions of the leaf, and leaving the veins and lower skin unmolested. As they increase in size they enlarge their web

by connecting it with the adjoining leaves and twigs; thus as they gradually work downwards their web becomes bulky, and as it is filled with brown and skeletonized leaves and other discolored matter, as well as with their own old skins, it becomes quite an unpleasant feature in our public thoroughfares, parks and orchards. The caterpillars always feed protected by these webs; but as soon as they approach maturity, which requires about a month, they commence to scatter, searching for suitable places in which to spin their cocoons. If very numerous upon the same tree the food supply gives out, and they are forced by hunger to leave their sheltering homes before the usual time. When the young caterpillars are forced to leave their webs they do not drop suddenly to the ground, but suspend themselves

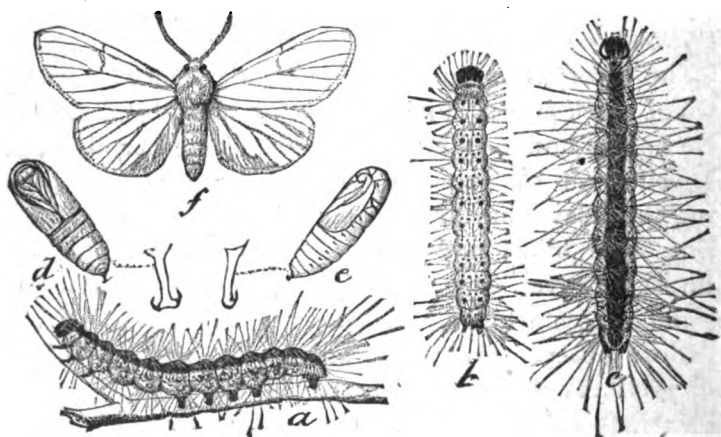


Fig. 82.—*Hyphantria cunea* Drury; a, b, c, differently marked caterpillars; d, e, pupæ; f, moth. From Div. of Entomology, Dep. of Agriculture.

by a fine silken thread, by means of which they easily recover the tree. Grown caterpillars, which measure 1.11 inches in length, do not spin such a thread. Both old and young ones drop themselves to the ground without spinning when disturbed or sorely pressed by hunger. Favorite recesses selected for pupation are the crevices in bark and similar shelters above ground; in some cases even the empty

cocoons of other moths. Fig. 82 shows different colored caterpillars, pupa and adult.

Passing the winter in the pupa state, the cocoons are found during the winter principally at the surface of the ground, mixed with dirt and rubbish, or in cracks and crevices of tree-boxes, in fences and under door-steps and basement walls. The first moths issue from these cocoons in May, and deposit their eggs in flat batches on the under side of the leaves. The young worms feed preferably in company, webbing first one and then several leaves together and gradually extending their sphere of action until a large part of the tree becomes involved. The worms become full grown in August.

REMEDIES:—Trees suffering from the attacks of this pest should be sprayed with London-purple or Paris-green. This will not be as effective as for most other insects, because the worms are protected by a web, which encloses the leaves they are feeding upon at the time, but as fresh leaves are constantly enclosed by the sheltering web the worms soon have to feed upon the poisoned ones and will be killed. If the branches are within reach the quickest method is to draw the branch through the hand and thus crush the worms and destroy their nest. If the branches carrying the web are still small, they may be cut off and thrown on the bare ground at a distance from the trees, or the worms may be crushed by stepping upon them. A good plan to destroy those nests, which are beyond reach of the hand, is to burn them with a torch of rags soaked with kerosene. It is even possible to destroy the majority of the worms in such a web by blowing them into space with a light charge of powder in a shot-gun. But whatever remedy is employed, it ought to be employed as soon as the nests become visible.

HICKORY TUSSOCK MOTH.

(*Halesidota caryn* Harr.).

Late in summer and all through the autumn, until late in September or until the leaves commence to drop, we find upon the hickory, apple, and other fruit trees and shrubs such as raspberries, etc., numerous caterpillars which are covered with short spreading tufts of white hairs, with a row of eight black tufts on the back and two long, slender black pencils on the fourth and on the tenth segments. The tufts along the top of the back converge on each side, forming a kind of ridge or crest; the warts from which these tufts proceed are oblong-oval and transverse, while the other warts on the body are round. The hairs on the fore part of the body are much longer than the rest, and hang over the head; the others are short as if sheared off, and spreading. The head, feet and under side of the body are black; the upper side of the body is white, sprinkled with black dots and with black transverse lines between the rings. These beautiful caterpillars are gregarious as long as young, but scatter later. When at rest they bend down the head and bring over it the long hairs on the fore part of the body; if disturbed they immediately roll up like a hedge-hog, and drop to the ground. The full grown caterpillars measure nearly one inch and a half in length. At this time they leave the trees, and move about in search of suitable shelters in which to make their oval and thin cocoons, almost entirely composed of their own felted hair. The pupa is short, thick and rather blunt.

The winged insects appear during June, and are sometimes found in very large numbers upon the early flowers of our milk-weeds. The moths are of a light ochre-yellow color, varying greatly in intensity; the rather narrow forewings are long and pointed, and are thickly and finely sprinkled with little brown dots, and have two oblique

brownish streaks passing backwards from the front edge, with three rows of yellowish-white, semi-transparent spots parallel to the outer margin. The hind-wings are very thin, transparent and without spots; the shoulder-covers are edged with light brown. The moths expand from one inch and seven-eighths to two inches and a quarter and more. At rest the wings are roofed; the antennæ are long, with a double, narrow, feathery edging in the males, and a double row of short, slender teeth on the under side in the females. These antennæ are rather longer than usual in Arctiids, and are not at all hairy. The tongue is a short spiral.

Another species of closely allied tussock moths is sometimes found feeding upon the foliage of plums; the more usual food is, however, the scarlet-oak. This moth is called *Halesidota maculate* Harr., or the Spotted Tussock moth. It is of a light ochre-yellow color, with smaller and almost white spots arranged in about the same manner as the yellowish-white spots in *caryæ*. The moth is a little smaller than the species described before. All three moths are shown on Plate XXI, Figs. 84 and 85.

THE CHECKERED TUSSOCK-MOTH.

(*Halesidota tessellata* S. & A.).

The caterpillar of this species is even more common, being found not alone upon the oak, but also upon plums, apples, raspberries and blackberries. In general appearance it is like *caryæ*, but the tufts are yellow, and the crest is a little darker; on the second and third segments are two orange-colored pencils, which are stretched over the head when the insect is at rest, and before these are several long tufts of white hairs; on each side of the third segment is a white pencil, and there are two pencils of the same color directed backwards, on the eleventh segment. The body is yellowish-white, with dusky warts, and the head is brown-

ish-yellow. They transform in similar hiding places to pupæ which winter over. Fig. 83, Plate XXI, shows one of these caterpillars.

The moths are much paler than those of *caryæ* and *maculata*, being only faintly tinged with ochre-yellow. Their long, narrow, delicate and semi-transparent wings lie almost flat on the top of the back; the fore-wings are checkered with darker ochre-yellow dusky spots arranged so as to form five irregular transverse bands. The hind edge of the collar, and the inner edges of the shoulder-covers are greenish-blue, and between the latter are two short narrow deep-yellow stripes; the upper side of the abdomen and of the legs are deep ochre-yellow. The wings of this moth expand about two inches.

FAMILY LIPARIDÆ OR TRUE TUSSOCK-MOTHS.

Tussock-moths are of medium size; the antennæ of both sexes, when winged, are pectinated, those of the males very broadly so; the wingless females have serrate or narrowly pectinate antennæ. The adult moths are usually very plain in coloration; the legs are clothed with woolly hairs, and when the insect is at rest the fore-legs are always stretched forwards and are very conspicuous. In some the females are practically wingless, the wings being at most mere useless pads. Most are nocturnal, though the males of some fly during the day. The larvæ are the most beautiful of our caterpillars, being clothed with brightly colored tufts of hairs.

THE WHITE-MARKED TUSSOCK-MOTH.

(*Orgyia leucostigma* S. & A.).

This caterpillar looks quite different from those of the other Tussock-moths described before. It is not a common insect in Minnesota, but is rapidly increasing in numbers.

At present it is almost entirely confined to our cities, where the caterpillars feed upon the foliage of such shade-trees as the soft maples, poplars, and cotton-wood. It is not unusual to find fastened to the trunks of such trees grayish cocoons, to which are usually fastened a mass of glistening white eggs. These latter attract the attention of the passer-by, who would not be apt to detect as readily the grayish cocoons of the males. Where these caterpillars have found a home in our orchards, the cocoons can also be detected late in autumn, or after the leaves have fallen, by investigating the dead leaves still fastened here and there to the branches of the trees; these almost invariably contain cocoons of such insects.

The eggs, which are deposited upon the outside of the cocoon, simply because the wingless female finds this the nearest and best place for this purpose, are found to be arranged in three or four layers; they are covered with a frothy mass that serves to protect them. From 300 to 500 eggs are found together; each egg is of a white color, nearly globular, and flattened on the upper surface. The eggs remain in this condition over winter, and hatch about the middle of May, when the young caterpillars immediately proceed to ascend to the foliage of the tree upon which they were born. These caterpillars are frequently called "Drop-worms," because they have the habit, when disturbed, of letting themselves down by a silken thread, remaining suspended until the danger is past, when they climb up again "hand over hand" to reach the leaf.

There are few caterpillars that are as handsome as this one, in spite of what may be said about worms never being beautiful. They are more than an inch long, of a bright yellow color, with the head and two small protuberances on the hinder part of the back of a brilliant coral-red. Along the back we see four cream-colored brush-like tufts, two long black plumes on the anterior part of the body, and one on the posterior. The sides are clothed with long and fine hairs.

A narrow black or brown stripe extends along the back, and a wider dusky stripe on each side. The peculiar cup-like, coral-red protuberance already mentioned are scent-organs used by the caterpillars to drive off enemies; they are used in a similar way as the whip-like organs found in the caterpillars of the swallow-tailed butterflies described before. As soon as the caterpillars reach their full size they descend to the trunk, or move to tree-boxes or fences, to find shelters in which to spin their cocoons, which are loosely made of silk and their own hair. It is a strange fact that the female caterpillar sheds her skin once more than the male. In Minnesota we have but one annual brood, at least in St. Paul and Minneapolis; further south two broods are the rule.

The brownish pupæ of the two sexes differ very considerably, the male being much smaller than the female; both are covered with short hairs.

The moths differ still more, the male being winged, with very broad and feather-like antennæ, while the female is wingless, possessing slender antennæ. The female is simply provided with the merest rudiments of wings, which are perfectly useless; her body is of a light-gray color, oblong-oval, with long legs, and is greatly distended with eggs. After leaving the pupal shell she does not leave the outside of the cocoon, but patiently awaits the male, when, after pairing, she commences to deposit her eggs in the manner already described; during this process her body shrinks more and more, and finally she drops down to the ground and dies as soon as her work is finished. The male moth is of an ashen-gray color; the fore-wings are crossed by wavy bands of a darker shade. There is a small black spot on the outer edge near the tip, an oblique blackish stripe beyond it, and a minute very characteristic white crescent near the outer hind angle. The gray body has a small black tuft near the base of the abdomen. The wings, when expanded, measure about an inch and a quarter across.

The males of some species of this genus of moths are diurnal in their habits, or fly swiftly during the brightest part of the day. Not so with *leucostigma*. Here the male rests during the day, and assumes a very characteristic position, as shown in the illustration, Fig. 87 and in Plate XXI.

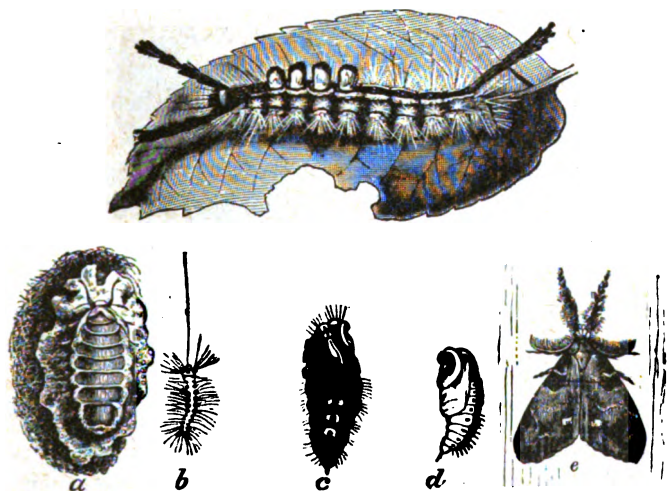


Fig. 87.

Fig. 87.—*Orgyia leucostigma* S. & A.; a, adult female on egg-mass; b, young caterpillar; c, female pupa; d, male pupa; e, male adult; above full grown caterpillar. From Div. of Entomology, Dep. of Agriculture.

The long and very peculiarly tufted forelegs are very conspicuous in this position, and as the colors of the moth blend well with the spot selected for rest the insect is not easily detected.

REMEDIES:—As the cocoons attached to the leaves or to the trunks of trees, sides of buildings, projecting roofs, under fence boards, etc., are easily detected, the eggs fastened to them can be collected in very large numbers and destroyed. But as the cocoons very frequently contain parasites it is best not to destroy them, but after having collected them to put them in an open box away from the trees. In this way the parasites can hatch and fly away, even the male moths may escape, but as the female moth has no wings there is

no danger that she can reach a tree some distance away. Spraying with arsenical poisons will also kill these voracious caterpillars.

THE PARALLEL-LINED TUSSOCK-MOTH.

(*Parorgyia parallela* G. & R.).

Another caterpillar, also ornamented with long pencils of hairs, feeds upon the plum, crab-apple, oak and other trees. It is sometimes quite common. It has a gray body, with a dorsal and stigmatal black line. The black pencils or tussocks are found on top of segments 4, 5, 6 and 7, the latter one is sometimes wanting; on each side of the first and last segment is a pencil of long black hairs; on top of segment 11 is also an apparently double brush of black hairs. The hair on the sides of the body is yellowish, in spreading clusters; on top of segments 9 and 10 is a small pale yellow cup. The head is of a shining-black. When full grown this caterpillar measures an inch and a half. It now searches for a protecting shelter, and here spins a coarse cocoon, inside of which it changes to a pupa. In *Parorgyia* both sexes are winged. The moths are dark gray, with darker colored wavy lines and spots; there is a dark blotch between the outer line and the apex. They resemble the males of *leucostigma*, but are a little darker and larger, as shown in Fig. 88, Plate XXI.

THE GYPSY-MOTH.

(*Ocneria dispar* Linn.).

This is also related to the Liparidæ. It is a European moth, which was imported into Massachusetts in 1868, and which has already caused enormous damage to that state, requiring annual appropriations of many thousands

of dollars, simply to keep it from spreading. It is not found in Minnesota, notwithstanding letters received from time to time, and it is to be hoped will always remain a stranger to



Fig. 89.—*Ocneria dispar* Linn.

our state. Its caterpillar, when full grown, is about one and one-half inches in length, of a creamy-white color, so thickly sprinkled with black that it seems dark-brown, the ground

color appearing in the broken dorsal and lateral lines. It is furnished with distinct dorsal and lateral tubercles, blue anteriorly and crimson behind the fifth segment, from each of which arise tufts of long black and yellowish hair. The caterpillar changes to a chocolate-brown pupa, covered by a few threads, forming the merest apology for a cocoon. The male moths are brownish-yellow, the fore-wings are smoky, with darker irregular transverse lines; the hind-wings are paler with a darker outer-margin. The heavier and much larger female moths are creamy-white in color, with irregular transverse gray or blackish lines. The males measure with expanded wings from one and one-half to two inches, the females two and one-half inches. The moths appear from July to September. The females deposit their eggs in masses of from four to five hundred in all conceivable localities, and cover them with yellow hair and scales from the end of their abdomen. The insects winter as eggs, which hatch from April to June.

FAMILY MEGALOPYGIDÆ OR FLANNEL-MOTHS.

Prof. Comstock has, for good reasons, separated from the *Liparidæ* a number of moths, which he places in a new family, the *Megalopygidæ* or *Flannel-moths*. They are whitish-moths which have their wings densely clothed with long and curly hairs, resembling bits of flannel. Their larvæ are also remarkable for the possession of ten pairs of legs, three thoracic and seven abdominal, while all other known lepidopterous larvæ have lost some of their abdominal legs. The cocoons are furnished with a trap-door.

THE WAVED LAGOA.

(*Lagoa crispata* Packard).

This peculiar caterpillar is quite uncommon in Minnesota, where it feeds upon a variety of plants, but especially upon the blackberry, apple and raspberry. Being quite uncommon it probably will never be classed among the injur-

ious insects. It is nearly oval, covered with evenly shorn hairs of a brownish color, which are raised to a ridge along the middle of the back, sloping off on each side like the roof of a house. When about three-fourths of an inch long, the caterpillar ceases to feed and forms now a tough, oval cocoon, which is fastened securely to the side of a twig upon the foliage of which it has been feeding. This cocoon is fastened very securely and can only be removed by applying some force. Inside this cocoon the caterpillar changes to a brown pupa.

The moth issues during July of the following year, and escapes by lifting a flat and circular lid on one end of the cocoon. It is a soft looking yellowish-cream or straw-yellow being; the fore-wings are more or less dusky on the outer margin, covered with fine, flattened, curled hair-like scales, arranged in regular waves, running from near the base to the tip. The body and legs are thick and woolly; at the tip of the abdomen there is a tuft of long and soft hairs, forming a bushy tail. The moth, with wings expanded, measures about one and three quarter inches across. It is shown in Fig. 90, Plate XXI.

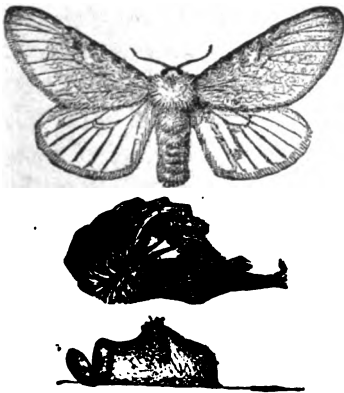


Fig. 91.

Fig. 91.—*Lagoa opercularis* S. & A.; larva, cocoon and adult. From Div. of Entomology, Dep. of Agriculture.

A closely related species, the *Lagoa opercularis* S. & A., is found in our Southern States. The moth resembles very closely the waved *Lagoa*. Its cocoon is about as interesting an object as we can find, and so closely resembles a terminal bud of the Life Oak, upon which the caterpillar is usually found, that it is almost impossible to detect it, especially as both twigs and cocoons are covered with small bits of

lichen. The larva, pupa and adult of this interesting moth is shown in Fig. 91.

FAMILY LIMACODIDÆ OR SLUG-CATERPILLARS.

A number of very interesting modest green or brown moths, usually of a small size, and very densely clothed with scales or hairs, form this family. They possess a much reduced head and have no tongue. The larvæ are very peculiar slug-like beings, usually flattened and oblong in shape, with no apparent legs; they move like slugs or snails, the prolegs being replaced by mere swellings on the abdominal segments. Some of these innocent or grotesque looking caterpillars can cause a burning pain like that produced by nettles; it is caused by the breaking of certain hollow spines filled with a powdery dust or which contain the same urticating acid in a liquid form.

THE GREEN SLUG-MOTH.

(*Parasa chloris* H. Sch.).

The caterpillar (Fig. 92, Plate XXII,) of this insect feeds upon cherry, apple and rose. It is of a bright scarlet color, with four dark blue-black lines along the back, and with prickly yellow horns or tubercles, which possess the power of stinging; the head is retractile. The ground-color of this caterpillar differs greatly, however, and in some cases it is yellowish or yellowish-brown. Like most species of *Limacodidæ* this caterpillar forms an egg-shaped cocoon, which is dark brown, smooth and very thin; in it the caterpillar hibernates, not changing to a pupa until spring.



Fig. 93.

Fig. 93 - *Parasa chloris*
H. Sch.; From Div. of
Entomology, Dep. of
Agriculture.

The moth is very pretty, have thing abdomen and hind-wings fulvous, the thorax and front-wings delicate green, the latter bordered posteriorly with brown, and having a patch of the same color at the base, one-third as long and one-half as wide as the wing itself. (Fig. 93).

A similar moth, the *Euclea pænulata* Clem., is not uncommon in Minnesota. A single caterpillar, found also upon the cherry, was bred in captivity, and proved to be this insect. The moth has a dark brown body, and the green marks of the front-wings are narrow and of a brighter green than in *chloris*. It is shown in Fig. 94, Plate XXII.

Still another moth is found from time to time near the electric light. It is *Euclea cippus* Cram. var. *quercicola* H. S. Its larva feeds upon apple, plum, cherry and some other plants, but is not common. The moth is also dark brown; the large green band on the fore-wings is in this case simply indicated by a number of large and small green spots, the one nearest to the body being larger and of a triangular shape. Fig. 95, Plate XX, shows two slug-caterpillars.

THE CHERRY SLUG-CATERPILLAR.

(*Adoneta spinuloides* H. S.).

The slug-like caterpillars of this moth are very curious grass-green objects, which, with their flat bodies ornamented with a few reddish lines, almost look like excrescences of the leaf. They move by a sliding and almost imperceptible motion. When mature they form very small and almost perfectly globular brown cocoons, fastened to leaves or twigs. In this condition they remain until spring, when they transform to pupæ and soon afterward to moths. (Fig. 96, Plate XXII). These are distinguished by a uniform dark brown color, with irregular bands of whitish spots. The rather falcate fore-wings are edged with brown and white. This insect is also uncommon, still a single small cherry tree was found, upon which several hundreds of these caterpillars were feeding. A rapid increase of this insect is not likely to take place, as but few of the caterpillars escape parasitic insects. Among these is a rather large and peculiar fly, the *Systropus macer* Loew, which is apparently much more bulky than the insect in which it fed.

SADDLE-BACK CATERPILLAR.

(Empretia stimulea Clem.).

The odd shape and very peculiar coloration, which is decidedly saddle-shaped, render this caterpillar a very striking object, and never fails to excite the wonder of those not versed in such things. But it sometimes excites something else than wonder! If handled roughly or carelessly the caterpillar can cause very severe pain. The thorn-like hairs, which grow upon it, sting like nettles, and when applied to the back of the hand, or to any other part where the skin is tender, the parts touched swell with watery pustules. The irritation caused by the acid in these thorns is sometimes exceedingly severe, and with some persons becomes a serious matter; first inflammation, next swelling, and in extreme cases a numbness or even partial paralysis of the entire arm. A prompt application of ammonia or bicarbonate of soda acts as an antidote, and soon allays the pain. This peculiar caterpillar is of a reddish-brown color, rounded above, flattened beneath, armed with prickly thorns, which are largest on the fourth and tenth segments, and with a bright pea-green patch, resembling somewhat a saddle in form, over the middle portion of the body, centred with a broad, ellipti-

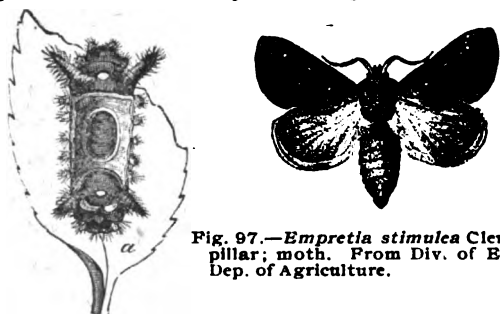


Fig. 97.—*Empretia stimulea* Clem.; a, caterpillar; moth. From Div. of Entomology, Dep. of Agriculture.

cal, reddish spot, the red spot and green patch both being edged with white. The under part of the body is flesh-colored. This caterpillar possesses six true legs but no prolegs.

The moths are of a deep, rich, reddish velvety-brown color, with a dark streak along the middle, extending from

the body half-way across, and on this is a golden spot; two other golden spots are on each wing near the apex. With expanded wings the moth measures nearly an inch and a half across.

These caterpillars are very general feeders, having been found on corn, sumach, rose, apple, grape, currant, cherry, raspberry and blackberry. Not being common, and much infested by parasites, it is not to be feared as a very noxious insect. Larva and moth are shown in Fig. 97.

THE HAG-MOTH CATERPILLAR.

(*Phobetron pithecium* A. & S.).

This is one of the most curious caterpillars known. Its slug-like actions, as well as its oblong or nearly square, flattened body of a dark brown color, make it a remarkable object. Its body is covered with eight singular fleshy appendages protruding from the sides. The three middle ones are longest, measuring about half an inch; they have their ends curved. When such caterpillars are roughly handled some or all of these fleshy horns become detached. The full grown larva spins a small round and compact cocoon, and to its outside the horns are fastened; the cocoon itself is usually fastened to a twig of the tree on which the caterpillars feed.

The moth is very uncommon. It is of a dusky purple-brown color, with ochreous patches on the back and a light yellow tuft on the middle pair of legs. The abdomen is sable, ending in a tuft of ochreous scales. The fore-wings are variegated with pale yellowish-brown, and crossed by a narrow, wavy, curved band of the same color, edged near the outer margin with dark brown, and having near the middle a light brown spot; the antennæ in the male are very broadly pectinated and the remarkably long and narrow fore-wings are partly transparent. The hind-wings are sable, bordered with ochreous in the female. The moth

measures with expanded wings, a little over one inch. This caterpillar feeds upon the cherry, plum, apple and oak. Larva and pupa are shown in Fig 98.



Fig. 98.—*Phobetron plithecium* A. & S.; caterpillar and cocoon. From Div. of Entomology, Dep. of Agriculture.

Mr. Hubbard, in "Orange Insects," gives the following account of this peculiar insect. "This insect receives its name from the curious hairy appendages which cover the back and project from the sides of the larva and have a backward twist, like locks of disheveled hair. They are, in fact, fleshy hooks, covered with feathery, brown hairs,

among which are longer, black, stinging hairs. The cocoon is almost spherical, and is defended by the hairy appendages which the larva in some way contrives to leave upon the outside. These tufts give to the bullet-shaped cocoon a very nondescript appearance, and the stinging hairs afford a very perfect protection against birds and other insectivorous animals. Unlike other species of *Limacodidæ* the Hag-moth larvæ do not seek to hide away their cocoons, but attach them to leaves and twigs fully exposed to view, with, however, such artful management as to surroundings and harmonizing colors that they are of all the group the most difficult to discover. A device to which this insect frequently resorts exhibits the extreme of instinctive sagacity. If the caterpillar can not find at hand a suitable place in which to weave its cocoon it frequently makes for itself more satisfactory surroundings by killing the leaves upon which, after they have become dry or brown in color, it places its cocoon."

THE SKIFF-SHAPED LIMACODES.

(*Limacodes scapha* Harr.).

The caterpillar of this moth is also very peculiar in form, being boat-shaped and triangular; it is green, spotted above

with brown, pale beneath, the sides raised, and the dorsal surface flattened. Late in autumn it forms a tough, rounded, oval cocoon. The moth appears in June; it deposits the eggs singly, and the larva often live on the upper side of the leaves. The caterpillar of this species is also a rather general feeder, being found upon apple, plum, cherry, hickory and oak. It is such a curious being that a more detailed description of it is quoted from H. Edwards and Elliot. "Ground-



Fig. 99.—*Limacodes scapha* Harr.

color pale apple-green. The segments extended laterally in the middle of the body, and raised into an elevated ridge, sharp and angular at the edges. The flattened portion, which includes the dorsal region, is chestnut brown, darker on the margins. There is also a darker dorsal stripe. The segments are arranged like the plates of a tortoise. The latter region is of a pale yellowish-green, with an oval white spot on segments 9 and 10. Spiracles pale brown, mouth parts also brown. In some specimens the brown color of the back is reduced to small patches, and occasionally a yellow dorsal line is present, the ground color (pale-green) then prevailing. Length 0.85, width 0.25 inch.

"The moth is light cinnamon brown; on the fore-wings the costa-median region is filled in with a large tan-brown triangular spot, ending on the tip of the wing, and is lined externally with silver. Expanse of wings, 26 to 28 mm."

Moth and caterpillar are shown in Fig. 99.

THE FASCIATED LIMACODES.

(*Lithacodes fasciola* H. S.).

This slug-caterpillar, as well as that of *Tortricidia flexuosa* H. S., are quite common in some years, and are rather general feeders. Both occur on the plum, cherry, apple, hickory, oak, linden and other trees. They cause but little damage, as they eat but little. There are still other species of Limacodidæ found upon our fruit trees, but as all are very similar in general habits and appearance it is not necessary to describe them in detail.

The caterpillar of *fasciola* is elliptical, the posterior end quadrate. The dorsal space is broad and flat; the lateral one broad and oblique. There is a slight, smooth and yellowish-green subdorsal ridge, and yellow subdorsal and lateral lines, of which the latter is broken. The depressed spaces are pale-yellow, with green centres. Length 7-13 mm.

The moth (Fig. 100) has ochreous-brown fore-wings, with a dentate white band running across the middle, followed by a blackish shade; there is a curved black line from the white band on the costa to the hind angle; the hind-wings are blackish or pale testaceous. Expanse 15-20



Fig. 100.—*Lithacodes fasciola* H. S.; moth. From Div. of Entomology, Dep. of Agriculture.

The caterpillar of *T. flexuosa* is elliptical; the dorsal space is almost uniform in width; the lateral space is broad and oblique; the dorsal ridge is very slight. Color pale yellowish-green, clearer at the sides. Subdorsal line yellow, as well as all the depressed spaces in the bottom, the largest with green centers. A number of very variable red spots and marks occur in the dorsal space, but the usual form is that of a rounded cross, of crimson color, marked with purplish-brown and blackish on the ridges.

All these species are single brooded, and can be found late in autumn, almost invariably on the under sides of the leaves, in which they eat large holes. All spin almost glob-

ular, brown and very thin-shelled cocoons, inside of which they hibernate as caterpillars, which do not transform to pupa until late in spring, and which soon afterward leave the cocoon, as moths, by round holes covered with perfectly fitting lids.

FAMILY PSYCHIDÆ OR BAG-WORM MOTHS.

As far as known none of these peculiar moths occur in Minnesota, though the writer has repeatedly received the peculiar bags from nurserymen, who had detected them on stock received from more southern states. The caterpillar builds for itself a silken sack covered with little twigs or bits of leaves. In this bag, which is made as soon as the worm hatches from the egg, it lives as in a house; it drags

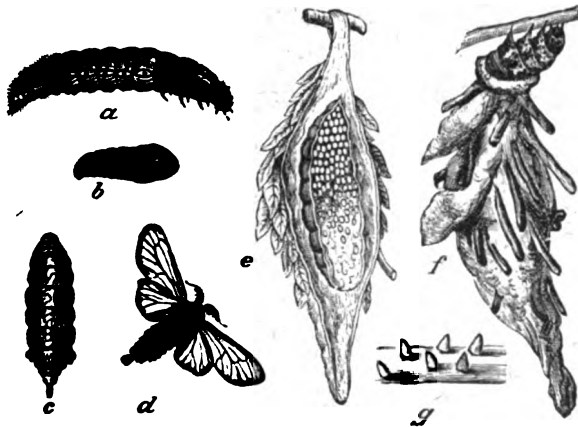


Fig. 101.—*Thyridopteryx ephemeraeformis* Steph : a, caterpillar; b, male pupa; c, female adult; d, male; e, female pupa filled with eggs; f, caterpillar in bag; g, young caterpillars carrying bags. From Div. of Entomology, Dep. of Agriculture.

it always with it like a snail, and fastens it by strong silken cables wherever it intends to feed. For the sake of those interested in the study of lepidoptera the bag of the common bag-worm (*Thyridopteryx ephemeraeformis* Steph.) is shown in Fig. 101.

FAMILY LACOSOMIDÆ.

Upon our low bushes of oak we find not rarely another peculiar house made by a caterpillar. It is the home of *Perophora Melsheimerii* Harr. Formerly this insect was



Fig. 102.—*Perophora Melsheimerii* Harr. Original.

classed among the insects belonging to the above family, but for very good reasons it forms now a family by itself, the *Lacosomidæ*. The moth is shown in Fig. 102 and the caterpillar in large illustration Fig. 134.

FAMILY NOTODONTIDÆ OR PROMINENTS.

This family includes moths of moderate size, only a few expanding more than two inches. Their body is stout, densely clothed with hair, of which those on the femora are unusually long. The strong wings are not very broad; the fore-wings have in many cases a tooth-like prominence on their inner margins. Many of the caterpillars have also peculiar humps, and thus become very prominent. They are either naked, or only thinly covered with hairs, and usually make slight cocoons or enter the ground for pupation.

THE SPHINX-LIKE APATELODES.

(*Apatelodes torrefacta* A. & S.).

This interesting moth is fairly common in Minnesota, but by no means sufficiently so to cause any great injury. Its caterpillar feeds upon blackberry, wild cherry, plum,

hazel, ash, willow and other plants. It is a very general feeder, hence varies in this respect from most of the other prominents. The hairy caterpillar is very conspicuous, and easily detected, as it feeds exposed on the leaves.

Prof. Beutenmueller gives the following detailed description of it: "Head dirty white. Body creamy white with a broken black dorsal stripe on which are tufts of hairs of the same color. A black spot on each segment along the sides. Body covered with long, white, flossy hairs directed backwards, except those on the anterior segments, which are directed forwards. On the back of each of the second, third and eleventh segments is a long, mouse-colored pencil, tipped with white at the ends. Abdominal legs black, the extremities pinkish. Thoracic feet black. Sometimes the body is pale yellow with the hairs bright sulphur yellow, with the pencils ferruginous, tipped with black. Sometimes the body is black with the hairs Maltese gray. Length 45 mm."



Fig. 103. *Apatelodes borrefacta* A. & S.

MOTH:—Fore-wings ash-gray, clouded outwardly with smoky brown. Across the basal third are two brown, parallel, wavy, narrow, transverse lines, and two similar ones across the outer third. On the inner margin near the base is a deep brown patch, and a small white spot beneath the apex. Hind-wings dull reddish, sometimes washed with ashen-gray, and with two ill-defined, transverse lines, the outer one whitish and marked at the inner angle with two deep brown dashes. Head and thorax ashen-gray, the latter with a deep brown band across the posterior part.

Abdomen gray, and tuft tipped with deep brown. Expanse, male, 36-40 mm.; female, 50 mm. The moth is illustrated in Fig. 103.

THE YELLOW-NECKED APPLE TREE CATERPILLAR.

(*Datana ministra* Drury).

This insect is not very common in our state, but is evidently on the increase in nurseries and orchards, and wherever found is quite destructive. It has found a home in some of our nurseries, where it can seriously injure the young trees, especially as the caterpillars are gregarious and thoroughly strip the infested plants of all foliage. When young they eat only the under side and softer part of the leaves, leaving veins and upper side untouched, but as they grow older and stronger the entire leaf, with the exception of the stem, is eaten. When full grown, which requires from

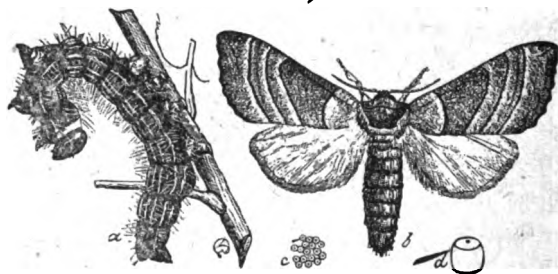


Fig. 104.—*Datana ministra* Drury; a, caterpillar; b, adult; c, eggs; d, egg enlarged. After Riley.

five to six weeks, they measure about two inches in length. They have a large and black head; upon the next segment the cervical-shield, sometimes called the neck, is of a dull orange color. Upon the back of the caterpillar we find a black stripe, and on each side are three stripes of black, alternating with four yellow stripes. White hairs, which are very long and soft, thinly clothe the body. As already mentioned the caterpillars are always found clustered to-

gether on a limb of the tree, and there form sometimes large bunches of worms. Each larva, when at rest, assumes a very odd and characteristic position; both extremities are raised, the body is bent, and rests only on the four pairs of prolegs, as shown in Fig. 104, *a*. If touched or otherwise alarmed they throw up their heads and tails with a jerky motion, at the same time bending the body until the two extremities almost meet over the back; they also sway their bodies from side to side. These jerky motions are intended to drive off marauding parasites, but frequently with but little benefit, as large numbers of the caterpillars are killed by such parasitic insects as the *Tachina*-flies. All caterpillars feed together, crowded upon the under surface of the leaves, and if we look closely we see along the margins a row of their shining black heads. When mature they all leave the tree, descending by night to the ground, where they burrow under the surface to a depth of from two to four inches. Here they change to naked brown pupæ, not enclosed in any silken cocoons whatever, and here they remain until the following July when the moths emerge.

Each female deposits from seventy to one hundred eggs in a single cluster on the surface of a leaf. Each egg is white and round, and all are placed firmly cemented together side by side in regular order.

The moth is of a reddish or russety-brown color, with the head and a large spot on the thorax chestnut-brown. The fore-wings are crossed by three to five transverse darker brown lines, one or two spots are near the middle, and the outer-margin is also of the same color. The hind-wings are pale-yellow and without markings. When the moth is at rest it has the posterior part of the body raised up and the fore-legs stretched out at full length. Both sexes of the moths are also shown in Fig. 105, Plate XII.

As this insect is seldom very numerous hand-picking at the proper time is all that is required. This is very easy, as the caterpillars feed together, and also cluster on the trunk

or lower branches during the moulting period, when the whole colony can be destroyed by crushing or burning.

There are a number of other species of the genus *Datana* which occasionally cause injury to our fruit-trees. Last summer (1898) two species were found in large numbers and were quite destructive to plums; the caterpillars had a somewhat different color but none could be reared to their winged form. All species of this genus have but one annual brood.

THE WALNUT CATERPILLAR.

(*Datana angusii* G. & R.).

This species closely resembles the *ministra*, but is a distinct kind, which is sometimes so destructive to our walnut and hickory trees, in the latter part of summer that they become denuded of all their leaves. The caterpillars are dark with light stripes along the sides. They assume the same peculiar position when at rest as the other species of *Datana*.

Two other species of *Datana* are found feeding upon the foliage of the apple, walnut, hickory and oak, i. e. *Datana integerrima* G. & R., and *Datana contracta* Walk.

The caterpillars of all the species of this genus have the habit of descending to the trunk of the tree to within a few feet of the ground, when about to moult, and to congregate here in a large mass. Large numbers of their cast-off skins are often very conspicuous after such moults and after the worms have disappeared long ago. It is, of course, very easy to capture at such times the whole colony and to destroy it. The application of arsenical preparations is of little use, unless the whole tree can be sprayed. But in nurseries, where the trees are still small and close together, it is in some cases advisable to apply such insecticides that do not alone kill the species of *Datana* but also the numerous other worms that eat their leaves.

Prof. Beutenmueller gives the following description of the species:

Datana angusii G. & R.

MOTHS:—Fore-wings varying from chocolate to deep smoky brown, differing in this respect from all the other species of this genus. Along the costal region the color is of a shade darker than the rest of the wing. Lines like those of *D. ministra*. Hind-wings paler. Thoracic patch very deep brown. Expanse 35-45 mm. Fig. 106 shows this moth.

CATERPILLAR:—Head and cervical-shield jet black, shining. Body black with three equidistant, very narrow, pale yellow or whitish stripes on each side, very much narrower than the intervening spaces. Under side with three yellow stripes,—one along the middle, which is the broader and one on each side, broken by the legs.

Abdominal legs and spots on the legless segments reddish. Thoracic feet black. Hairs on the body dirty white. Length 55 mm.



Fig. 106.—*Datana angusii* G. & R.

Datana integerrima G. & R.

MOTHS:—Fore-wings light brown with five transverse lines, followed by light shades. Over the wings are fine darker irrorations. Outer margin even, in the male, very slightly scalloped in the female, which is of a paler shade. Two discal spots. Thoracic patch dark ochreous. Hind-wings paler. Expanse, 35-45 mm. Fig. 107, Plate IV, shows this moth.

CATERPILLAR.—Body wholly black, covered with long, floss-like, white hairs. Sometimes there are visible a subdorsal, ill-defined, white stripe, a rather broad, wavy,

lateral stripe and one along the middle of the under side. Head jet black, shining, rarely chestnut red. Abdominal legs black outside and reddish-brown inside. Length, 55mm.

Datana contracta Walker.

MOTH.—Pale tawny luteous, with numerous dark brown or blackish irrations. Lines as in *integerrima*. Discal spots present. Hind-wings and body pale luteous. Thoracic patch dark ochreous. Expanse, 35-45 mm.

CATERPILLAR.—Head black. Cervical-shield orange. Body black with four creamy-white stripes along each side, as wide as the intervening spaces, and three stripes beneath. Abdominal legs yellowish-brown, extremities black, and with yellowish-brown spots on the legless segments. Thoracic feet black, bases yellow-brown. Length, 55mm. Fig. 108, Plate IV, shows this moth.

THE RED-HUMPED CATERPILLAR.

(*Edemasia concinna* S. & A.).

As far as habits are concerned this insect resembles the Yellow-necked Apple-tree Caterpillar very much. The forewings of the moth are dark brown on the inner and grayish

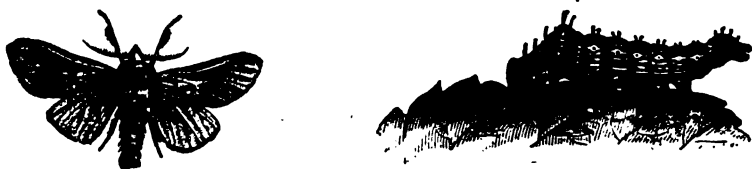


Fig. 109.—*Edemasia concinna* S. & A.. Moth and caterpillar.

on the outer margin; they have a dark brown dot near the middle, and a spot near each angle, and several longitudinal streaks of the same color along the hinder margin. The hind-wings of the male are brownish, those of the female

dusky brown; the body is light brown, the thorax of a darker shade. With wings expanded they measure an inch and a quarter across.

The female, which appears late in June, deposits her eggs in a cluster on the under side of a leaf. The tiny caterpillars at first only consume the substance of the under side of the leaf, but as they soon increase in size they devour the entire leaf. When not engaged in eating they huddle closely together and frequently completely cover the branch upon which they rest. While resting the posterior part of the caterpillar is always elevated. The young caterpillars are similar to, but lighter colored than the mature ones. These latter are greenish-yellow or yellowish-brown; the head and a prominent hump on the back of the fourth segment is coral-red. The body is striped longitudinally with dark brown or black lines; or, considering all the colors, with yellowish, white and dark lines. A double row of black spines extends along the back, and five black points are found on each side of the segments, three above the spiracles and two below. The back is marked with five narrow black lines; the sides from the fifth to the tenth segment, inclusive, are whitish with black lines above the spiracles. The first three segments are spotted with black and white; the last segment is spotted with black. The legs are black; the prolegs black and yellow, the last segments taper a little. When full grown the caterpillar is one inch and a quarter long.

These caterpillars are gregarious, and soon defoliate the branch on which they were born. When handled they discharge a transparent fluid which possesses a peculiar acid smell and which no doubt serves as a defense against enemies, especially birds, which can readily see these caterpillars so openly exposed in large numbers.

When mature the larvæ descend to the ground, where they conceal themselves under leaves upon or slightly under the surface. Here they surround themselves with a very thin

cocoon, of a silky texture, yet looking more like a cell made of glue than of silk, inside of which they change to a brown pupa, which remains in the cocoon until the next year. Both larva and adult are shown in Fig. 109; the larva also in Fig. 110, Plate XIV.

These caterpillars are rather general feeders, being found upon the apple, their favorite food, but also upon plum, cherry, rose, shad-berry, *Wistaria* and other plants. As they are gregarious during their entire larval existence and can

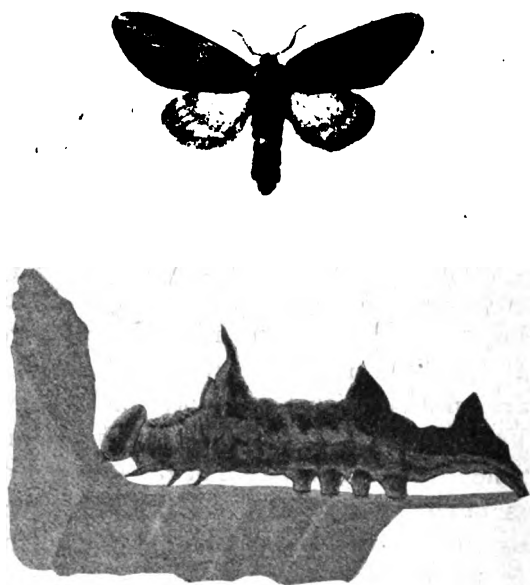


Fig. 111.—*Cedemasia eximia* Grote; moth and larva. After Packard.

readily be seen, they can be easily detected and destroyed, especially in nurseries, where the limb inhabited by them can be cut off and where the worms can be trampled under foot. A sudden jar of the limb will also bring the caterpillars to the ground where they can be killed.

Another species, the *Cedemasia eximia* Grote., occurs also on the apple, willow, maple and other trees.

The moth (Fig. 111) resembles *concinna*, but is a little

larger, with longer and more produced wings. Its forewings are ashen-gray, with dashes of ochreous brown; the inner margin for two-thirds of the width of the wing is purplish-brown; there are no transverse lines; the very small discal spot is round and black and a short black dash is found at the base of the wing. The hind-wings are grayish-brown, darker in the female.

The caterpillar has a dirty white head, with a band on each side composed of brownish-black spots, dotted with red. The body is pale brown, with a brownish-olive shade along the back, quite distinct on the last four segments, and frequently quite greenish. The distinct V-shaped mark is pinkish; an oblique olive-brown line runs from the base of the long and fleshy tubercle on the fourth segment backwards to the anterior part of the leg on the sixth segment. This movable tubercle is long, with the distal half slender. A slight hump occurs on the eighth and a larger one on the twelfth segment.

THE UNICORN PROMINENT.

(*Schizura unicornis* S. & A.).

The caterpillar of this moth is also a very peculiar being. It is brown or reddish-brown with a pea-green patch on each side of the first three segments, and variegated with white on the back, with a large brown head. The fourth segment is furnished on the upper side with a long, horn-like and acute tubercle with two small tubercles at the tip and from the possession of this horn the species has been named. On the eighth segment is a slight hump with two small warts and on the last segment is a rather large dorsal hump supporting two warts. On the body are a few short and scarcely visible hairs. The last segment and the last pair of feet are always raised when the caterpillar is at rest, but are used when walking. These odd-looking worms are not common, but may be found during August and September.

ber when they have reached their full size. According to Saunders, the caterpillar "at first eating a notch, about the size of its body, in the side of the leaf on which it is feeding, and placing itself in this notch, with the humps on its body somewhat resembling the irregularities in the margin of the partly eaten leaf, is not easily detected." Yet notwithstanding this similarity to the edge of the leaf, expressed still more so by a similar caterpillar, that of the related *Ianassa lignicolor*, there are few worms that are as thoroughly parasitized by Tachina-flies as these apparently so well hidden and protected ones. The mature caterpillars measure an inch and a quarter in length. They do not possess the gregarious habits as some of those already described, being either found singly, or three or four together on the same twig. Towards September the caterpillar descends to the ground, and here it constructs under fallen leaves or other rubbish a thin and almost transparent papery cocoon and very much later it changes to a brown pupa, in which state the insect hibernates.

The moth is not a showy insect, having the fore-wings light brown, variegated with patches of greenish-white, and

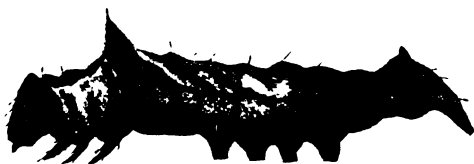


Fig. 112.—*Schizura unicornis* S. & A. After Packard.

with many darker brown wavy lines, two of which enclose a small whitish space. The hind-wings of the male are dirty white, with a dusky spot on the inner hind angle; those of the female are sometimes entirely dusky. The body is brownish, with two narrow black bands across the front part of the thorax. The moth spreads nearly an inch and a half.

The mimicry of the larva has already been mentioned; that of the moth is equally interesting. It always rests head downwards, with the legs all drawn together, and its wings folded round the body, which is stretched out at an angle of about 45 degrees, the dull gray coloring of the wings with its lichen-green and flesh-colors give the whole a perfect resemblance to a piece of rough bark so that the deception is perfect. Caterpillar and moth are shown in Fig. 112 and in Fig. 113, Plate XIX.

These caterpillars are also general feeders and occur in some numbers on the plum, apple, rose, dogwood, elder, wintergreen, blackberry and raspberry. They can not be called very injurious, as they are not common enough in our State.

THE LONG-HORNED PROMINENT.

(*Schizura ipomeæ* Doubleday).

This insect is also not very common in our State, but as its larva feeds not alone on oak, maple, birch, etc., but also on the blackberry and raspberry, and perhaps on the plum, it is best to mention what is known about it. The caterpillars vary considerably, but usually they are green, speckled with purple. There is also a faint sub-stigmatal sulphur-yellow line, most distinct on the thoracic joints, and a broad pale sub-dorsal line between which the dorsum is pale lilaceous, but thickly mottled with rich purple-brown and ferruginous, leaving a narrow dorsal line distinctly marked. Two elevated ferruginous warts occur on top of joints 4 and 11. The head is large, dark green, with a distinct lateral black and white stripe. The caterpillar differs from that of *unicornis* chiefly by the spine on the front abdominal segment, which is almost three times as large and high and which ends in a deep fork, each tine of which bears a stiff truncated spine. When full grown the caterpillar makes an earthen cocoon, regular oval in shape, covered

with sand on the outside. Like all members of the Prominents the larva remains a long time unchanged inside this cocoon, which is one reason why in captivity the adult insects are so difficult to rear.

"The moth is purplish-gray, tinged with sea-green at base and along costa of the fore-wings; frequently with a buff-colored apical patch in the male. Discal spot black, linear, and followed by a blackish shade. Transverse lines faint, blackish, wavy, the outer lines succeeded by a reddish-brown shade. A series of subterminal dashes, and a few white marks. Hind-wings whitish in the male, dark-gray in the female. Expanse 30 mm." Both moth and caterpillar are illustrated in Figs. 114 and 115, Plate XIX.

Two other Prominents occur in Minnesota, and sometimes they are found in large numbers, showing that their larvæ, which feed on the leaves of the apple, hawthorn, walnut, basswood, maple and oak, are more or less injurious, though they never have been numerous enough to cause serious injury. The descriptions given by Beutenmueller, in his "*Descriptive Catalogue of the Bombycine Moths, etc.*," are given below.

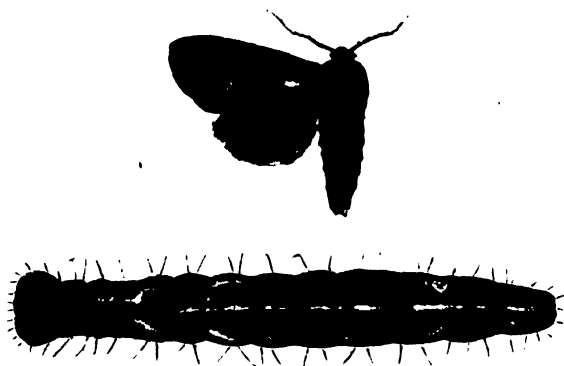
Heterocampa manteo Doubl.

"**MOTH.**—Fore-wings ash-gray, varying from light to dark gray, with three scalloped, darker, transverse lines, the scallops filled with light gray. A large discal pale-gray spot containing two small black dots; costa before apex with short black dashes. Terminal edge notched with black dots. Hind-wings uniform mouse color, fringes paler. Expanse, 40-50 mm.

"**CATERPILLAR.**—Head dull opaque umber, with a broad darker brown line edged with white on each side meeting the vertex. Body green with a broad subdorsal and two narrow yellow lines. The sides of the first three segments dotted with reddish pink, and there is a reddish streak on

the outside of the anal legs. The subdorsal lines diverge on the first segment, and on the next two segments are edged within with pinkish red lines. The space between the dorsal lines is more or less filled with pinkish-red, and with a narrow yellow line along the back, beginning on the fourth segment. Body elongate, with slight traces of a hump on the last segment, otherwise smooth. Length, 35 mm. Double brooded and not common. The caterpillar is subject to variation, especially in the red markings along the back; sometimes the space between the subdorsal stripes is filled in solidly with deep red, and only interrupted by the yellow dorsal line. It spins a rude cocoon on the ground or under the surface."

The moth and caterpillar are shown in Figs. 116 and 117.



Figs. 116 and 117.—*Heterocampa manteo* Doubl. Moth and Caterpillar.
After Packard.

Heterocampa guttivitta Walker.

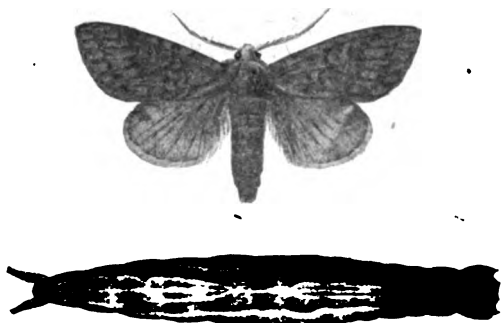
"Fore-wings whitish-gray, with darker shades; the markings are like those of *H. biundata*, but the subterminal row of spots is straight, and not bent as in the latter species; hind-wings gray. Expanse, 40-50 mm.

CATERPILLAR:—Head large with a short, lateral four-colored stripe of black, white and pink with the outside yellowish. Body green, finely speckled with dark red brown

along the sides. Dorsal line snow white fading into yellowish on the sides, where there is a series of fine dark red black dots; the line is widest on the fifth and sixth segments and at the sature of the seventh and eight segments connects by a narrow neck with the posterior division of the oand, which contains a whitish line in the middle, bearing reddish dots on each side. Sides of the tenth to the twelfth segments white, including the upper part of the anal legs, which are marked with a red line. Thoracic feet green, with a black dot in the middle. Length, 35 mm.

Not common and possibly double brooded, the very young caterpillar is reddish brown with nine pairs of long horns like the antlers of a deer. The first pair are much longer than the rest, each with four very long branches."

The moth and caterpillar are shown in Figs. 118 and 119.



Figs. 118 and 119.—*Heterocampa guttivitta* Walk. Moth and Caterpillar.
After Packard.

THE FORKED-TAIL CATERPILLAR.

(*Cerura borealis* Bdv.).

There are few caterpillars that are more odd and peculiar in form, posture and motion, than those of the genus *Cerura*. Their body is naked, short and thick, tapers behind, and ends with a forked kind of tail, which is held upwards at an obtuse angle with the rest of the body. This

forked tail, which takes the place of the hindmost pair of legs, is not used in creeping, but is used as an organ of defense. It consists of two movable hollow tubes, within each of which is concealed a long orange-colored thread or flagellum, which the insect can push out and draw in at will. If the caterpillar is disturbed it suddenly erects and separates the two tubes, and pushes out the brightly colored whip-like threads, which, as they lash any intruder, give off at the same time a peculiar odor, no doubt offensive to the same. The caterpillar of *borealis* feeds upon the wild cherry and other allied plants. Its head is reddish-brown. The first very broad segment is square in front on the sides, and ends in a low projection, which looks somewhat like the hood of a monk. The body is pale yellowish-green, with a dorsal median reddish-brown band, beginning at each angle on the first segment, and narrowing on the second and third segments, it begins to widen again on the fourth, becoming widest on the seventh, and extending down each side near the base of the abdominal legs; it contracts and becomes narrowest on the end of the tenth segment, and widens a little on the last. The red patch is sometimes more or less interrupted by the ground color. The anal-plate is triangular, rounded at end; the tails are long, brown, with three pale rings on the outer half. Thoracic feet deep red; abdominal legs pale, tips reddish.

The caterpillars eat a flat depression into wood, over which they spin an oval cocoon, mixed with particles of wood. This cocoon is difficult to detect and very hard.

The moth has a white head and thorax, the latter being bluish-black in the center. The fore-wings are white, with a very broad grayish-black median band with irregular edges, contracting about the middle. Outside is a blackish shade across the wing. The space between the band and shade is white, with two distinct black spots on the costa, followed by two rows each of four small spots. The outer and basal parts of the wings are white, the former with a terminal

row of black spots, the latter with a row of four black spots and one spot near the base of the wing. The hind-wings of male are whitish with a small black discal spot, a terminal row of spots and a dusky patch at hind angle; in the female the hind-wings are dusky. Expanse, 38-43 mm.

The curious caterpillar is shown in Fig. 120; the moth in Fig. 121, Plate XIX.



Fig. 120.—*Cerura borealis* Bdv, caterpillar. After Packard.

FAMILY SATURNIIDÆ OR GIANT SILK-WORMS.

Among this family we find the giants of North American moths, some of them expanding four inches and more; in the tropics they are represented by moths that have a spread of wings sometimes fully twelve inches. The larvæ of all spin more or less bulky silken cocoons, and are interesting on that account as the silk could be made of use, being very strong. Formerly the genuine Chinese Silk-worm was classed among these insects.

THE CECROPIA SILK-WORM.

(*Attacus cecropia* Linn.).

The great size and peculiar coloration of this large silk-producing caterpillar (Fig. 122) makes it an object easily recognized. It is nearly four inches long, of a pale limpid-green color, and as thick as a man's thumb. It bears on the third and fourth segments large warts or tubercles of a coral-red color, which resembles small ripe strawberries; the other tubercles on the back of the caterpillar are smaller and yellow, excepting those on the last segments which are blue.

Both the front and hind-wings of the adult (Fig. 123, Plate XIII) are of a rich brown, the anterior pair grayish, shaded with red, the posterior more uniformly brown, and about the middle of each of the wings is a nearly kidney-shaped white spot, shaded more or less with red, and margined with black. A wavy dull-red band crosses each of the wings, edged within with white, the edging wide and distinct on the hind-wings, and more or less faint on the front pair. The outer edges of the wings are of a pale, silky brown in

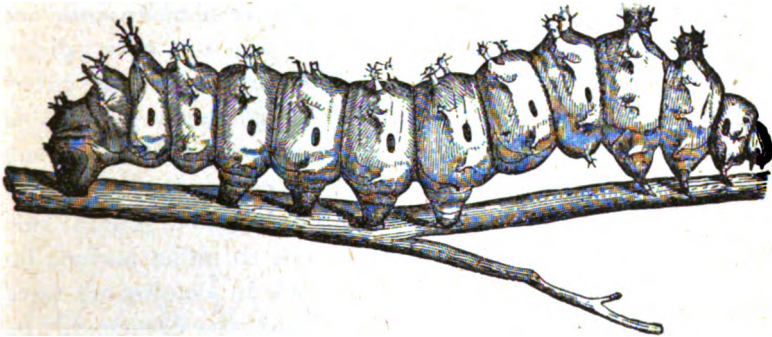


Fig. 122.—*Attacus cecropia* Linn.; caterpillar. After Riley.

which, on the anterior pair, runs an irregular dull-black line, which on the hind-wings is replaced by a double broken band of the same hue. The fore-wings, next to the shoulders, are dull red, with a curved white and black band, and near their tips is an eye-like spot with a bluish-white crescent. The upper side of the body and the legs are dull red, with a wide band behind the head and the hinder edges of the rings of the abdomen white; the under side of the body is also marked with white.

The cocoon is about three inches long and an inch or more broad in its widest part, pod-shaped, of a rusty gray or brownish color; it is formed of two layers of silk, the outer one not unlike strong brown paper, and within this a quantity of loose silken fibres covering an inner, oval, closely woven cocoon, containing a large brown pupa. Snugly enclosed within this double wrapper the pupa remains unin-

jured by the variations of temperature during the winter. Late in May or early in June the pupal case is ruptured by the struggles of its occupant, and the newly born moth begins to work its way out of the cocoon; to lessen the labor a fluid is secreted about the mouth, which softens the fibres; then a tearing, scraping sound is heard, made by the insect working with the claws on its fore-feet, pulling away the softened threads and packing them on each side to make a passage for its body.

The natural enemies of this species are usually sufficient to present an undue increase of these voracious caterpillars, but if for some reasons such enemies are absent the caterpillars become very numerous and destructive. This is especially true in the windbreaks in our open prairies, where they cause sometimes considerable trouble. Orchards and nurseries also suffer from time to time, but as a general rule these insects are not numerous enough to inflict serious injury. Their large size, and their work in defoliating trees and shrubs, soon attract attention, and they can readily be removed by hand-picking. The caterpillars are destroyed by numerous parasitic insects, chief among which are Tachina flies, (Fig. 124, Plate XIV.) the Long-tailed Ophion (*Ophion macrurum*), the Cecropia Chalcis-fly (*Smicra mariæ*), Cecropia Cryptus (*Cryptus extrematis*) and others. Birds are also effective in destroying both caterpillars and pupæ; the Hairy Wood-pecker eats the pupæ of a large number of cocoons during the winter. Many others are destroyed by the Blue-Jay, and by our odoriferous friends the Skunks, who find most of the cocoons formed near the ground.

The caterpillars of this moth are very general feeders, and in 1882 in Papilio a list of 49 species of plants belonging to 20 genera was given as their food plants. Since that time many other plants have been found that are to the taste of these voracious feeders, and among them apples, plums, cherries, all kinds of small fruit with the exception of the grape-vine; other cultivated plants also furnish food.

THE POLYPHEMUS SILK-MOTH.

(Telea polyphemus Linn.).

The caterpillar (Fig. 125) of this large moth is quite different from that of the *cecropia*, being of a limpid light yellowish-green color, with seven oblique pale yellowish lines on each side of the body; it lacks the prominent tubercles, but has in their place little black wart-like processes which give rise to small and stiff bristles. The segments, which have the spaces between them deeply in-

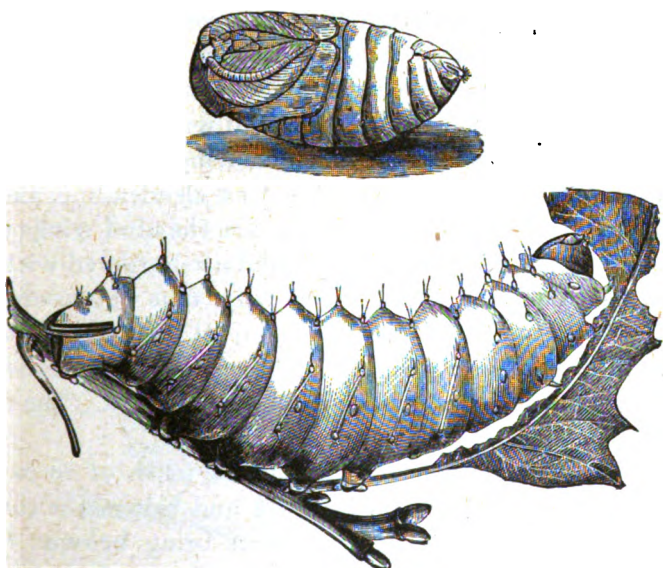


Fig. 125.—*Telea polyphemus* Linn.; caterpillar and pupa. After Riley.

dented, are each adorned with six wart-like processes or tubercles, which are sometimes tinted with orange; each segment has a small silvery spot on the middle. The head and anterior feet are pale-brown, the spiracles pale-orange, and the terminal segment is bordered by an angular band resembling the letter "V," of a purplish-brown color. When mature the caterpillar spins a cocoon and selects for this purpose the leaves of the tree upon which it fed, by

drawing them together and by fastening some of them very firmly to the outside of the cocoon. This latter is oval in shape, of a brownish-white color, and is completely closed, differing in this respect from that of the *cecropia*, which is open at one end. As a general rule the cocoons drop to the ground with the leaves in autumn and remain there.

Late in the spring the moth appears. It is shown in Fig. 126, Plate XIII. Its wings expand from five to six inches, and are of a dull, ochre-yellow color, sometimes of a rich buff, or inclined to a pale-gray or cream color, or they possess a deeper and almost brown color. Towards the base of the wings they are crossed by an irregular pale-white band, margined with red; near the outer margin is a stripe of pale purplish-white, bordered within by one of rich brown. About the middle of each wing is a transparent eye-like spot, divided transversely by a slender line, and encircled by yellow and black rings. On the hind-wings these spots are more eye-like in shape, and are bordered with yellow, with a line of black edged with blue above and the whole set in a frame made of an oval spot of rich dark-brown, the widest portion of it being above the eye-spot, where it is sprinkled also with bluish specks. The front edge of the fore-wings is gray.

The eggs, which measure about one-tenth of an inch in diameter, are slightly convex above and below, the convex portions being whitish, and the sides being brown. Each female deposits upon the under side of leaves from two to three hundred eggs, which hatch in the course of about ten days. While the female is flying about and engaged to deposit these eggs she looks very much like a bat.

This handsome insect has, like the *cecropia*, feathered antennæ in both sexes; those of the males are very broad, almost looking like a third pair of small wings. These antennæ contain an immense number of sense organs. The females, which do not fly before their eggs are fertilized, are quite sluggish until that time. Virgin females can be utilized

to "semble," which means that large numbers of males can be attracted to them and can thus be collected and killed.

This insect has also many enemies which usually keep it in check. It is also a very voracious and general feeder, eating the foliage of plum, apple, walnut, butternut, rose, oak and others.

THE LUNA MOTH,
(*Actias luna* Linn.).

There are few insects as beautiful as this moth, which has an expanse of wings of about four and a half inches. The hind-wings, instead of being rounded as is usual with moths, have the anal part extended into a broad tail, curving somewhat outward, an inch and three-quarters beyond the rest of the outer margin. The color of the wings varies in intensity, but they are usually of an even, delicate, bluish-green color, sometimes verging into yellowish, with a little eye-like spot on each wing consisting of a small clear center

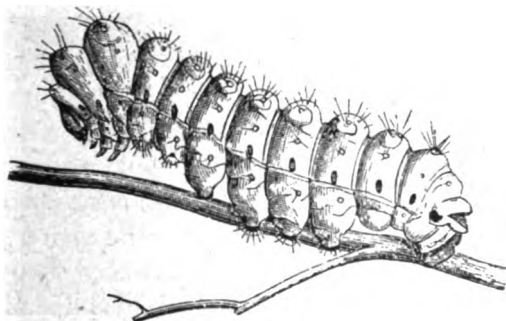


Fig. 127.—*Achias luna* Linn. Caterpillar. After Riley.

encircled with lines of red and black. The anterior border of the fore-wings is broadly margined with purple or purplish-brown; the same color occurs upon the collar, feet and legs; the body of the moth is of a soft white. (Fig. 128, Plate XV.)

The caterpillar (Fig. 127) of this striking moth resembles somewhat that of the *polyphemus*. It is of a clear, pale bluish-green color, with a yellow stripe on each side of the body; the back is crossed between the segments by transverse lines of yellow. On each segment are about six minute, pearl-colored warts, tinged with purple or rosy color; from each arise a few hairs. At the extremity of the body are three brown spots edged with yellow. When full grown it draws together several leaves, fastens them with silken threads, and spins inside this hollow space a cocoon very much resembling that of the preceding species; it falls like it to the ground with the leaves in autumn. The cocoon is quite thin and papery and so compact that it can not well be unwound.

The colors of the moths vary according to the food consumed by the caterpillars. If fed on the foliage of hickory their color is yellowish-green, if on black walnut it is a much more vivid green, and the markings and borders are much darker and more plainly marked. In fact, in some very brightly colored specimens there is a wavy band of purple parallel to the outer borders.

This insect occurs in Minnesota wherever hickories and walnuts grow, but as the caterpillars are also much preyed upon by parasites it is not likely to become a serious pest.

Still another species of native silk-worms has been reported from the state, but must be very uncommon, at least no specimens have been seen by the writer. It is the Prometheus Moth (*Callosamia promethea* Drury). The sexes of this moth differ greatly, both in shape of wings, in color, and in the pattern of their marking.

THE IO EMPEROR MOTH.

(*Hyperchiria Io* Linn.).

This is also a very beautiful insect (Fig. 129, Plate XVI), but it is not as common as the other silk-producing species. The sexes vary very greatly, both in size and color. The

smaller male is deep yellow, with rather faint purplish-brown markings; on the fore-wings are two oblique wavy lines near the outer margin, a zig-zag line near the base, and other blackish dots and markings. The hind-wings are of a deeper ochre-yellow, and are shaded with purple next the body; within the hind margin is a curved purplish band, and inside this a smaller and darker one, while in the middle of each hind-wing is a large, round and blue eyes pot, with a broad black border and a central white dash. The antennæ of the male are beautifully feathered; the wings measure, when expanded, about two and a half inches across. In the

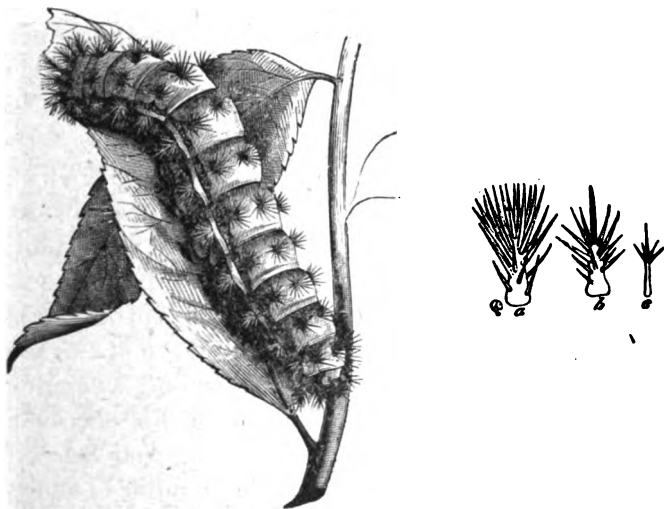


Fig. 130.—*Hyperchiria Io* Linn.; caterpillar; a, b, c, branching spines, enlarged. After Riley.

female the wings are purplish-brown, the transverse lines gray and much more prominent, and there is a somewhat dusky, pale-margined, nearly kidney-shaped discal spot; the hind-wings are very similar to those of the male; the thorax and legs are purplish-brown, the abdomen ochre-yellow, with a darker edging on each ring.

The female deposits her eggs in clusters of twenty or thirty. They are about one-sixteenth of an inch long, top-shaped, of a creamy-white color, with a yellowish spot above. When young the dark-colored caterpillars produced from one cluster of eggs are gregarious, following each other in regular order, but as they grow older they scatter, each shifting for itself. The caterpillar (Fig. 130) reaches its full size during August, when it measures two inches and a half in length. It is now of a delicate pale green color, paler and whitish along the back, with a broad brown stripe edged with white and reddish lilac on each side; the breathing-pores are yellow, ringed with brown. The body is covered with clusters of green and branching spines, tipped with black, which arise from small warts, of which there are a number on each segment. These spines are very sharp and possess strong urticating properties, so if the insect is handled carelessly the points of the spines enter the skin, and breaking off fill the wound with an acid, which can produce on the more tender portions of the skin a considerable irritation accompanied by redness and raised white blotches, very similar to those caused by the common stinging nettle. The irritation is, however, not so great as if produced by the spines of the larvæ of some of the slug-worms. As soon as mature the caterpillar descends to the ground, where it spins a thin, irregular and somewhat parchment-like cocoon made of tough, gummy and brown silk, among and below dead leaves and other rubbish. The enclosed pupa is short and thick, pale-brown, and is ornamented with a few reddish bristles on the abdominal joints and a tuft of the same at the end.

These stinging caterpillars are also very general feeders, being found on a great variety of plants, among them plum, apple, currant, thorn, corn, clover, elm, oak, willow and others.

If this insect ever becomes numerous it can easily be subdued by hand-picking, providing the necessary cau-

tion is taken to guard against its poisonous spines, which will, however, not penetrate through thick gloves. A large number of parasites are not afraid of this well-armed caterpillar and usually keep it in check.

FAMILY HEMILEUCIDÆ OR HEMILEUCIDS.

This small family contains but a few rather large and conspicuously marked insects. The antennæ are broadly pectinated in the males and narrowly so or nearly serrate in the females. There is only a single pair of teeth to each segment of the antennæ. The thorax and abdomen are usually thickly clothed with long woolly hair. But one species occurs in Minnesota.

THE BUCK MOTH OR MAIA-MOTH.

(*Hemileuca maia* Drury).

This is still another caterpillar which is much more poisonous than any of those already described. It is very common in Minnesota, and feeds on the wild cherry and apple, but chiefly on the red oak and willows, where it can cause considerable damage, as it is a most voracious feeder. The caterpillar is brownish-black, with six spined tubercles on each segment, except on the eleventh, where there is only one dorsal tubercle; an additional one is found on segments one to five, and also on segments ten to twelve. The spines on these tubercles are more or less branched; some are truncate at the tip and bear bristles. Those on the back are rusty-yellow, tipped with black, with a few wholly black in the center of each branch. The other branched spines are black with the blunt ends white, and the spinules arising from them dusky. The breathing-pores are pale and narrowly oval. The underside of the caterpillar is yellowish along the middle; the head is light-reddish-brown; the thoracic legs are also light brown, but the prolegs are lighter, inclining to Venetian red. When full grown the caterpillar measures a little over two inches in length. Fig. 131 shows the caterpillar, and Fig. 132, Plate VIII, the moth.

The sting of these caterpillars is really quite severe, and it is not easy to handle them with impunity. The insects themselves lack the power of stinging us, and it is simple carelessness on our part if we are injured at all. The effect of these stings is violent pain, a reddening of the punctured parts, and the early appearance of raised whitish blotches, followed later by purplish spots, which do not disappear for several days.

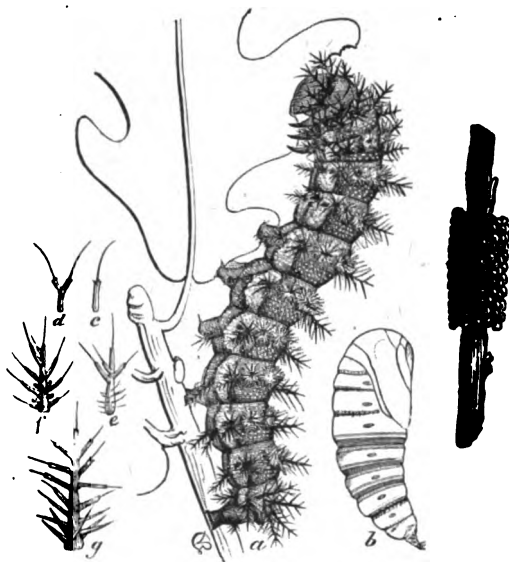


Fig. 131.—*Hemileuca maia* Drury; eggs; a, caterpillar; b, pupa; c, d, e, f, g, spines. From Div. of Entomology, Dep. of Agriculture.

When mature all the caterpillars, which are gregarious throughout their existence, enter the ground, and there in a simple oval cell, each one sheds its prickly skin and assumes the pupal state. The pupa is of a deep brownish-black color, heavy, rounded anteriorly, and minutely roughened, except the sutures of legs and wing-sheaths, where it is smooth and polished. The abdomen ends in a triangular, flattened and ventrally concave tubercle, which is topped with a few curled, blunt, and rufous bristles.

The moths, which fly here in Minnesota late in September and the first part of October, differ in habits from those of most other genuine moths by flying in mid-day. They are modest-looking but truly elegant insects. Their wings are so lightly covered with scales that they are semi-transparent, and look like delicate black crape. The bands across them are creamy-white, and broadest on the hind-wings. These bands vary greatly in width, and some are almost obsolete, while in other cases they are very broad. The male differs from the female in having broader black antennæ and a smaller abdomen, tipped with a large tuft of brick-red hair. Its color is cream-white, and the black hairs of the body are more or less sprinkled with hairs of the same pale color. The female has the lower side of the antennæ, the hair on the thighs, and two small tufts behind the thorax of a brick-red color. She deposits her eggs (See Fig. 131) in naked belts of from 100 to 200 eggs; these are only fastened together by a little glue and are not deposited in perfect order. Each egg is obovate, about 0.05 inch long, compressed at the sides and apex, and of a dirty yellowish color.

There are some very curious points in the life history of this moth. The caterpillars, all born at the same time, from eggs deposited by one mother, feed side by side upon the same plant until mature when all enter the ground at about the same time and transform to pupæ. Yet out of 200 pupæ thus formed at the same time early in July only 117 moths issued in the same year, while the rest remained in the ground fully a year longer when most of them issued.

FAMILY CERATOCAMPIDÆ OR ROYAL MOTHS.

This is a small family of fairly large or very large moths, the caterpillars of which are usually furnished with horns, spines or similar processes. The moths are sometimes contrastingly colored, and distinguished by having the antennæ in the male feathered for only a portion of the distance.

As a general rule these insects are not injurious to our fruit-trees, but infest other trees, such as oaks and maples. They not infrequently become so numerous and destructive that but few leaves are left on the oak trees covering many square miles and one can not step upon the ground under the trees without stepping upon some of these hungry worms. One

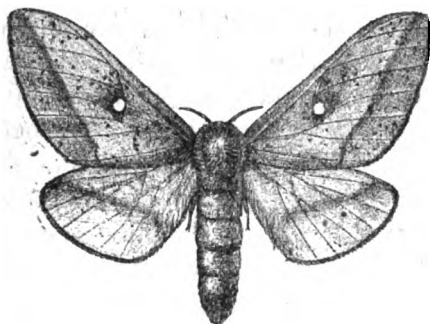


Fig. 133.—*Anisota senatoria* Hub.; male below, female above. Original.

species, however, is found not alone on the oak, but occurs also upon the raspberry and blackberry. It is the Orange striped Oak-worm (*Anisota senatoria* Hub.). The caterpillars have a jet-black head; the body is dull-black, with four dull-orange stripes along each side, and a trace of a fifth stripe along the base of the legs; all the stripes run to the end of the eleventh segment; the last segment is black. The under side is marked with a broad yellow stripe along the

middle. On each side of the second segment is a slender, long, slightly curved horn, and along each side of the body three rows of short spines. The caterpillars, of which we have only one annual brood, measure 45 mm. in length. A caterpillar is shown with other oak feeding caterpillars in Fig. 134.

The sexes of this moth vary greatly. The male has ochreous-brown wings with a purplish tinge; the fore-wings are semi-transparent in the middle. There is a conspicuous white, round discal spot and a dark oblique line, from a little before the apex across the wing, parallel with the



Fig. 134.—1. *Janassa lignicolor* Walk.; 2. *Anisota senatoria* S. & A.; 3. *Anisota virginiana* Dru.; 4. *Edema albilabris* S. & A.; 5. *Datana ministra* Dru.; 6. *Porthos melaleuca* Harr.; 7. *Acanthosia impressa* Walk.; 8. *Gastrophysa americana*.

outer margin. The hind-wings are opaque. The female is very much paler in color; it expands from 45-60 mm., the male from 30-38 mm. Both sexes are illustrated in Fig. 133.

FAMILY BOMBYCIDÆ OR TRUE SILK-WORMS.

The Genuine Silk worm (*Bombyx mori* Linn.) belongs here. It is not a native of the United States, but is frequently bred in this country either for its silk or for curiosity. The moth, which in course of time has become dwarfed to such an extent as to be unable to fly, is cream-colored, with two or three more or less distinct brownish-lines across the



Fig. 135.—*Bombyx mori* Linn.

fore-wings. The head is small; the antennæ are pectinated broadly in both sexes. The silk-worms are usually fed upon the leaves of the mulberry, but not upon those of our Amer-

ican species, which are unsuitable. The wilted leaves of the osage orange can also be used. The different states of this important moth are shown in Fig. 135.

FAMILY LASIOCAMPIDÆ OR LASIOCAMPIDS.

This family includes the destructive tent-caterpillars and the lappet moths. The adults are stout-bodied and hairy moths of medium size. The antennæ are pectinated in both sexes, those of the males being usually longest.

TENT-CATERPILLARS.

There are but few insects that are better known to persons interested in fruit and shade trees than the different kinds of tent-caterpillars, which occur throughout the northern regions of the globe, and of which numerous species have been described. All are similar in general appearance and habits. In the United States they are called "Tent-caterpillars," because here one of the most common species is distinguished by its habit of forming a large silken tent for the home and protection of a whole community of worms. All tent-caterpillars, however, spin a large amount of silk, only their tents are not as conspicuous as in the above species. In Europe, but especially in Germany, they are called "Ringelspinner" from the small ring or ringlet-like egg-masses, which the females deposit around a small twig of the tree selected for this purpose. The illustrations show that both popular names are well selected, since they express a habit readily perceived.

In Minnesota we have to deal with two species of tent-caterpillars, which are always common in certain well-defined localities, and sometimes exceedingly so, as for instance in 1898, when in many parts of the State they devoured the foliage of all kinds of trees growing in orchards and forests. Few insects have a more interesting life-history

than these caterpillars, and it pays to study it carefully, as by so doing a number of excellent remedies will suggest themselves and can be used to assist us in a war against them.

THE ORCHARD TENT-CATERPILLAR.

(*Clisiocampa americana* Harr.).

The adult insects of this species measure with wings expanded a little more than one and a half inches; they are reddish-brown, and the fore-wings are tinged with gray on

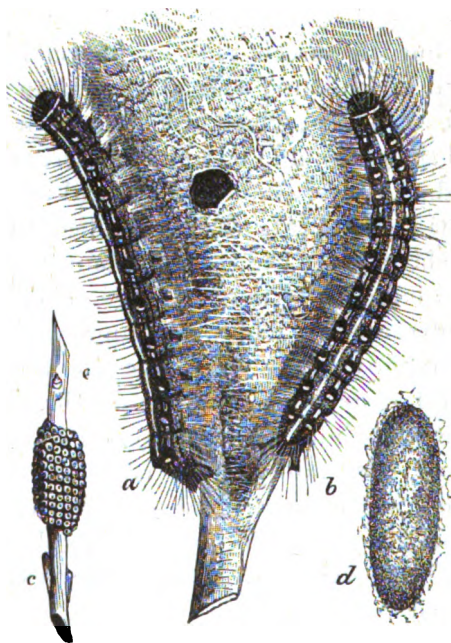


Fig. 136 — *Clisiocampa americana* Harr.; a, b, mature caterpillars; c, egg mass; d, cocoon. After Riley.

the base and middle, and are crossed by two oblique lighter stripes. As they fly only at night they are not often seen; in places, however, where powerful electric lights are used many are attracted and thus can be collected in large num-

bers. The moths take no food, hence they can spend all their energy to search for suitable places in which to deposit their eggs. In this manner they sometimes fly a long distance, and especially after a time when the great majority of the nearly grown caterpillars had been killed by a contagious disease; in fact it almost seems as if the moths which had escaped this disease realized the danger and tried to avoid it and to protect their future off-spring against it by migrating to places where the insect, and the disease, had not occurred for some years. Since this disease is very apt to occur whenever the insects have been very numerous for three years in succession in any one locality, we have the reasonable assurance that after that period the insects will disappear from the locality for some time. But as some of the healthy moths escape they start colonies in new regions and as the resulting caterpillars are healthy, they soon increase very rapidly until they are again killed off by the same fatal disease. All attempts to breed and multiply this useful disease by artificial means have failed thus far, but no doubt means will be found in future to utilize it against these destructive caterpillars. In 1898 the disease appeared in a small grove of trees, and the writer took numerous diseased caterpillars to other groves infested with healthy worms. Still other diseased worms were sent long distances to forests invaded with tent-caterpillars, and wherever introduced the disease broke out amongst the healthy worms, and soon destroyed the greater majority of them. Many other forests, as badly infested with these worms, showed no sign of this disease, and it would be more than accident if such places had escaped while others had not. There seems to be but little doubt that this disease can be spread artificially in case we can find diseased worms at the proper time. Two breeding cages were prepared which contained the eggs of healthy moths; at least in the places from which the eggs were taken no disease appeared in the following season.

The breeding-cages were kept in different parts of the same building. In one case the caterpillars were fed with leaves moistened with the crushed substance of diseased caterpillars, and soon afterwards the disease showed itself by killing nearly all the caterpillars in that cage; the worms in the second cage were fed on leaves not so prepared and all matured and formed moths. Equally good results were obtained with a disease destroying the worms so injurious to cabbage, and both cases show that under certain conditions much good can be done by gathering diseased caterpillars and by bringing them in contact with healthy ones.

After mating the females deposit their eggs (about 300 in number) in a belt or ring around the twigs of plum, cherry, shadberry, apple or a few other trees. This takes place early in July. These egg-masses are coated with a thick glue which serves as a protection against moisture and, perhaps, against the cold weather of autumn, winter and spring. Very likely this glue is a non-conductor of heat; at all events the eggs do not usually hatch until the following spring, even if kept in warm rooms. These rings of eggs are readily seen at a time when all the foliage has disappeared from the trees, and they should be removed at that time, which is easily done. Fig. 136 shows a ring of eggs; also two adult caterpillars and a cocoon.

About the time that the buds begin to swell in the spring (about the middle of April in Minnesota) the eggs hatch, and the young caterpillars select some fork of a twig where they form a small nest for themselves. By selecting a fork they can utilize the twigs as tent-poles, around which they build a nest with several openings or doors. Here the colony rests, either inside or on the outside of the tent. As long as the caterpillars are still soft and tender they are most frequently found inside their house, and only during the warmer portion of the day do they bask in the sun upon its outside. As the caterpillars grow they add to this tent until it becomes a very bulky affair partly filled with excrement

and the old skins of the inhabitants. The tents (Fig. 138, Plate XVII), when opened, will be found to contain numerous blackish caterpillars with yellow and bluish spots and covered with very fine grayish hairs, which prevent any moisture from reaching their skins. The illustration shows two of the full grown caterpillars, which are rather pretty insects, if caterpillars can be so called. When hatched they measure about one-tenth of an inch in length; they are blackish and covered with fine gray hairs (Fig. 144, Plate XXIII). They feed on the young and tender leaves, and eating on an average two leaves a day, the young of one pair of moths consume from ten to twelve thousand leaves, and as it is not uncommon to find from six to eight nests on a single tree not less than seventy-five thousand leaves are devoured; a loss which no tree can long endure.

As the caterpillars grow they cast their skins from time to time. In about thirty-five or forty days they have reached their full size; they are about two inches long, with a black head and body, having numerous yellow hairs on the surface. A white stripe marks the middle of the back, and minute white or yellow broken and irregular streaks are found along the sides. Along each side of the back is a row of small transverse pale-blue spots. Fig. 137, Plate XVII, gives an illustration of the larva.

While young the caterpillars are social in their habits. When they leave their tent to feed, which they do twice every day, they move as a regular army, and as they go they spin a continuous thread of silk from a fleshy tube on the lower side of the mouth, which is connected with silk-producing glands in the interior of the body. By means of this thread they find their way back to the tent, which is the product of the combined efforts of all the caterpillars from one ring of eggs. The caterpillars feed only on warm and dry days; during cold and damp weather they remain in the tent. As soon as full grown they leave their home and scatter in all directions, each searching for some pro-

tected spot in which to spin its cocoon. When sheltered spots have been found, usually under projecting objects, such as roofs and upper fence-boards, they spin spindle-shaped cocoons of white and almost transparent silk; when finished they fill the spaces between the silken threads with a sulphur-yellow substance, which in drying becomes a powder. Inside these cocoons (most beautiful objects) they change to pupæ, from which emerge, in from twenty to twenty-five days, the moths, ready to start another brood for the following year. This caterpillar, although quite numerous in Minnesota, has not created as much alarm as the one described next.

THE FOREST TENT-CATERPILLAR.

(*Clisiocampa distria* Hub.).

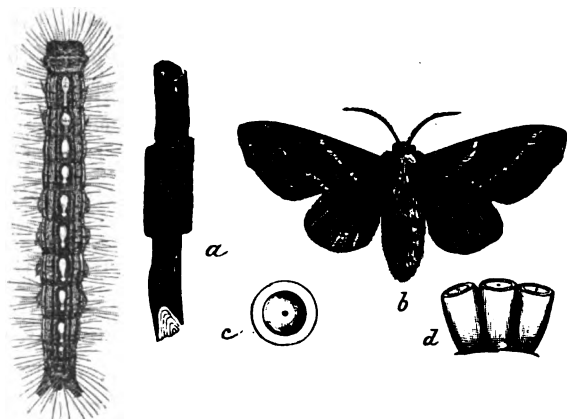


Fig. 139.—*Clisiocampa distria* Hub.; caterpillar; a, egg-mass; b, moth; c, top of enlarged egg; d, three enlarged eggs. After Riley.

This caterpillar (Fig. 139) is even more common than the Orchard Tent-caterpillar which it closely resembles. It does not, however, construct a large tent. The caterpillars feed upon the foliage of various species of forest trees, such as oak, ash, maple, etc., but they prefer linden or bass-wood; they

are also very injurious to plum, cherry, apple and other fruits. The moth (Fig. 140, Plate XVII), which expands an inch and a half or more, is brownish-yellow. It has on the fore-wings two oblique brown lines enclosing a darker space. The eggs are about one twenty-fifth of an inch long and one-fortieth wide; they are arranged three or four hundred in number in the form of a ring around the twigs of trees. These clusters differ from those of the other tent-caterpillars in being uniform in diameter and cut off squarely at the ends. The individual eggs are white; they are covered with a brown varnish-like substance. The eggs hatch also early in spring, and the young caterpillars have sometimes to wait for some time before the trees furnish any food, but as they are very hardy they have been known to live in cold weather for three weeks without eating. The writer kept them under melting ice for four days without injuring them in the least; in fact, as soon as thawed out they seemed to show increased appetite. But as the buds expand and the young leaves appear the worms make up for lost time. Like the other tent-caterpillars they spin a silken thread wherever they go; they are also gregarious as long as young, but scatter when older. They march in regular order, feed twice a day and when not thus engaged they crowd together, most frequently upon the trunk of a tree (Fig. 141, Plate XIX). In such positions they also undergo their moults, and not infrequently large numbers of their empty skins are found together, held in position and to the tree by numerous threads (Fig. 142, Plate XIX). The caterpillars, when fully grown, are a little smaller than their relatives upon orchard trees. Their general color is pale-blue, tinged with green on their sides, and everywhere sprinkled with black dots or points, while along the middle of the back is a row of white spots, on each side of which is an orange-yellow stripe, below which is another cream-colored one. All these stripes are edged with black. Each segment of the caterpillar has two elevated black

points on the back, from which arise a number of coarse black hairs. The back is clothed with whitish hairs; the head is dark blue, freckled with black dots, and clothed with black and fox-colored hairs; the legs are black, clothed with whitish hair. Fig. 143, Plate XX shows these caterpillars.

When mature these caterpillars wander on fences, houses and along roads in search of suitable shelters in which to form their cocoons, which are a little more loosely constructed than those of the other tent caterpillars. After having finished these cocoons they transform in two or three days to reddish-brown pupae densely covered with short, pale yellowish hairs. Two or three weeks later the moths appear which soon afterward deposit their eggs and die.

Tent caterpillars have few enemies and only few parasites are known to attack them. Some carnivorous beetles, as the large black ground beetle, *Calosoma frigidum* devour large numbers; the green *Calosoma* has been reported to even enter the tents to devour these worms. The skunk also eats large numbers of the wandering caterpillars. Our two species of Cuckoos make it a regular business to feed upon these worms which no other birds will eat. This useful bird is shown in Fig. 145.



Calosoma frigidum.
Original.

REMEDIES.—Many methods have been suggested for the destruction of these caterpillars. In case of orchards or smaller trees the most available and economical way to nip the evil in the bud is to remove the cluster of eggs wherever found and to burn them. In the case of small trees this is easily done, as the egg-masses remain on them during all the time when the leaves have dropped, and as the former are easily seen they can as readily be re-

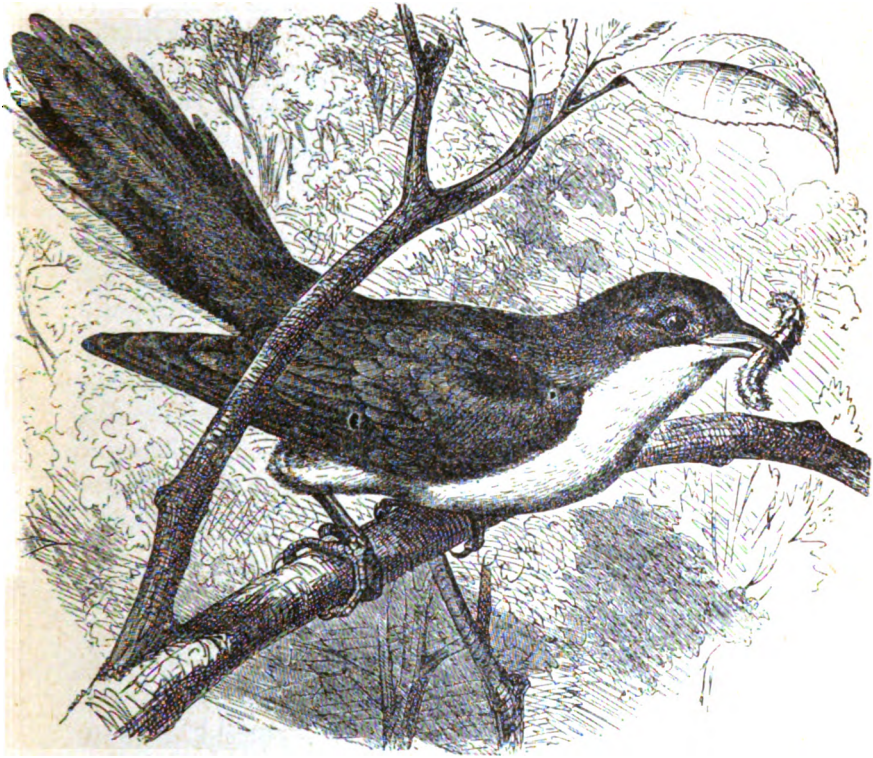


Fig. 145. American Cuckoo or Rain-crow eating hairy caterpillar. From Brehm's Thierleben.

moved. This is at least quite easily done in our orchards, but when it comes to destroying such eggs on forest trees this is not an easy matter, though nearly all egg-masses will be found concentrated upon the twigs of linden. In case of the Orchard Tree tent-caterpillars the white tents made by them are readily detected, and they should be destroyed as soon as possible. This should be done when the caterpillars are at home, i. e. early in the morning or towards evening; during the middle of the forenoon and in the afternoon they are away from their nests and are engaged in feeding. As long as the tents are small and can be reached they and their entire contents should be crushed with the hand protected by a glove or mitten. If they can not be reached in this way the caterpillars can be destroyed by thrusting a rag soaked with kerosene and fastened to a pole, into the tent and by twisting the pole all worms will come in contact with the oil, which will kill them. Burning torches applied when the tent is occupied will also kill the worms but the flame is apt to injure the trees. Of course united action is necessary, for if a single orchard is neglected and permitted to become a breeding-place not alone of the tent-caterpillars but of many other kinds of noxious insects, it is sufficient to stock and restock all neighboring orchards. If all fruit growers in any given region would destroy all the tents on their trees, even for a single season, the work of destroying the caterpillars in the following year would be greatly lessened. In fact it would well pay to offer a small bounty to children for collecting eggs or the small nests still containing the worms. It should be remembered that each ring of eggs, and each small tent, contains from 300 to 400 minute caterpillars which if permitted to grow can cause great injury.

One of the best remedies is the use of Paris-green sprayed upon the foliage of the infested trees. The writer has made numerous experiments with this substance, and has found that the large caterpillars are as readily killed as those just

hatched, and that it does not require a large amount of poison to do so. One pound of Paris-green to 100 gallons of water, or one pound to 150 gallons of water, sprayed upon apple trees, had the effect of burning the foliage and injuring the trees very materially. By using one pound of this poison to 200, 250 or even 300 gallons of water all caterpillars were killed in the course of from one to three days. If London-purple is used, one pound to 300 gallons of water will do the work. In both cases it is best to add to the mixture some lime water, which will neutralize any free acid, and in this way prevent injury to the trees to be protected.

THE VALEDDA LAPPET-MOTH.

(*Tolype velleda* Stoll.).

This uncommon insect is sometimes found in its larval state (Fig. 146) feeding upon the foliage of the apple, cherry



Fig. 146.—*Tolype velleda* Stoll.; caterpillar.

and plum; it also feeds on the oak, elm, lilac and poplar. The caterpillar is hairy and it hides so well in the cracks of the tree, into which its body fits very tightly, that it is not easily detected; it looks very much like an excrescence of the bark, especially as the side fringes, which border close to the under surface and are composed of spreading tufts of light gray, mingled with black hairs, hide so thoroughly the edges of the caterpillar's body. It has a small and flat head, nearly hidden between two projecting tufts of hair from the second segment; it is bluish-gray and is marked with numerous longitudinal lines; on top of segment three there is a transverse black band, most distinct when the insect is in motion. On top of each segment are two warts, those on segment three in front of the black band are the largest; each of these

warts gives rise to a few black hairs. There is also a stig-matal row of large warts, from each of which proceeds a cluster of light gray hairs, interspersed with a few black ones. The under side is of a pale red or orange color, with squarish black spots. When full grown it reaches a length of two inches and a half. Late in July it spins a very dense cocoon, about an inch and a half long and half an inch wide, oval, convex above, and flattened on the under side, of a brownish-gray color.

The sexes of this moth, which is found in August and September, vary considerably in size, the male being much smaller, measuring only from an inch and a half to an inch and three-quarters, while the female measures two and three-quarters inches. The fore-wings of this delicate looking moth are gray, crossed by two double, slightly wavy, white lines at the end of the first and second thirds of the length of the wing, and a single line of the same color near the outer margin. The hind-wings have only the outer line. The body is milky-white, with a large, blackish spot on the middle of its back; that part of this spot which is on the thorax is composed of beautiful, glistening and erect scales, while the caudal part of it consists of recumbent hairs. This moth differs from most other moths by having the body covered with long hairs; it is shown in Fig 147, Plate XXIV.

THE AMERICAN LAPPET-MOTH.

(*Gastropacha americana* Harr.).

This is a very interesting insect and rather common. The moth (Fig. 148 and Fig. 149, Plate XXIV), which



Fig. 148.—*Gastropacha americana* Harr. Original.

occurs in two colors, is quite remarkable on account of the fact that when resting it so closely mimics a dead leaf, that even trained eyes are apt to be misled. Most examples are of a tawny, reddish-brown

color, with the hinder and inner edges of the fore-wings and the outer edges of the hind-wings deeply notched; these notches are edged with white. Both pairs of wings are crossed by a rather broad, interrupted whitish band, which on the fore-wings does not always reach the front margin. In the female the pale bands and dark lines are sometimes wanting, the wings being almost entirely of a red-brown color. The moth measures with expanded wings nearly one inch and three-quarters across.

The white eggs have peculiar black markings and are most beautiful objects under a magnifying glass. They are deposited on the leaves of the apple, cherry and oak late in June. The caterpillar is also very difficult to detect, as it hides during the day on the twigs of trees and is only active at night. It possesses a broad body, convex above and perfectly flat beneath, which, when fully extended, very closely resembles a natural swelling of the bark. It is of an ash-gray color fringed close to the under side on each side with tufts of blackish or gray hairs, springing from projecting tubercles. The caterpillar (Fig. 134) is easily recognized by a bright scarlet and velvety band on the posterior part of the third segment, and by a similar one on the fourth; both of them are only visible when the larva is crawling. There are a number of small tubercles on the segments from which grow tufts of grayish hairs mixed with white ones. The under side of the caterpillar is orange colored, with a central row of square blackish spots. The mature larva measures fully two inches in length. It spins a peculiar gray cocoon which looks very much like a slight swelling of the twig to which it is fastened. The brown pupa remains in it until the month of June of the following year. This insect feeds on apple, poplar and some other plants.

FAMILY COSSIDÆ OR CARPENTER-MOTHS. .

Moths of this family are, according to recent writers, very low in the scale of development. The adults, also

known as "Goat-moths," from a rank odor peculiar to them, have rather narrow strong and pointed wings and long, spindle-shaped, naked bodies, and some resemble quite closely the hawk-moths in this respect. Their head is small, very much retracted, and the tongue is obsolete, so that the insect is unable to take food. Their nearly naked caterpillars are all wood-borers, living from two to four years in the trunks or roots of trees.

THE GOAT-MOTH.

(*Prionoxystus robiniae* Peck).

This moth (Fig. 150) is by no means uncommon in Minnesota, being frequently attracted to the electric light. It

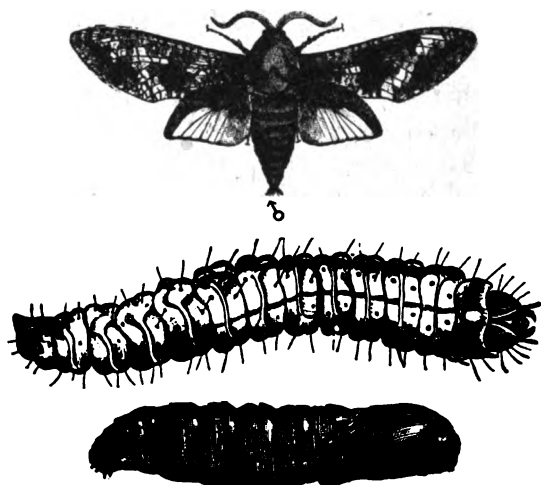


Fig. 150.—*Prionoxystus robiniae* Peck; male, caterpillar and pupa.
From Division of Entomology, Dep. of Agriculture.

passes its larval state in such trees as locust, elm, poplar, oak and others, being but rarely found in the trunks of crab-apple. Still there is a possibility that it may become more common, and consequently more destructive, as our apple orchards become more numerous and the trees older.

The caterpillar lives in the trunk and larger limbs of the infested trees. It has a pale greenish-white body with a tinge of pink or yellow; sometimes a reddish-pink band occurs on the anterior part of each segment, except the third or fourth and the last one. It has a dark colored dorsal line; segments two and three have a brown spot on the top, and on each side of segments four to eleven inclusive are three piliferous spots above the spiracle, arranged in the form of a triangle. These piliferous spots are brown or pink. The under side of the caterpillar is greenish-white, the cervical shield dark or yellowish-brown; the head dark brown, with a somewhat lighter colored face; the jaws are stout, prominent and pitchy. These large and bad smelling worms reach a length of about two inches and a half. When full grown they spin a loose cocoon in the burrow, inside of which they transform to a rather slender, cylindrical pupa, which is furnished with a series of spines around the edges of each segment. When ready to emerge as a moth the pupa twists and wriggles through the bark, and for half its length out into the open, holding fast by the spines on the abdominal segments. The larvæ live in the trunk of trees about three years before coming to maturity. The moth issues late in June or early in July.

The two sexes of the moth differ both in size and in color. The female, which expands from two to two and a half inches, has gray wings marked with irregular black lines and dots. The male, which expands only an inch and a half, has the fore-wings much darker, and the hind-wings are golden or ochre-yellow. There are but few scales upon the wings of these moths.

The eggs are deposited in the crevices of the bark about the first of July, and usually older trees are selected for this purpose. The large eggs are glued so tightly to the surface that they can not be removed without destroying them, and yet they are still so soft when just deposited that they fit any crack, no matter what its shape. Several hundreds of

them are deposited by a single female. The young and dark brown caterpillars, with very large heads, bore as soon as hatched in various directions into the trees, but usually in an oblique direction upward or downward, increasing the cavity as they grow larger and lining the same with silk as they go. Remedies are difficult to provide. If the caterpillars are found in destructive numbers in any one locality some valuable trees may be protected by washing the bark about the last of June with soft soap to which is added a little Paris-green or London-purple, which is apt to prevent the moth from depositing eggs upon trees thus protected, and to kill the young larvæ when they leave the eggs and eat their way into the tree.

FAMILY NOCTUIDÆ OR OWLET-MOTHS.

This family of moths is rather uniform, and the species are very much alike. The head is distinct, not sunken into the thorax, as in the Bombycidæ; the palpi are stout, projecting in front of head, but not more than the length of the head; the antennæ are filliform, slightly ciliate, or in the males of some species slightly pectinate. These moths possess a robust body; the thorax has more or less prominent shoulder-tufts, frequently very distinct dorsal tufts, and usually prominent transverse tufts on the prothorax. The abdomen is frequently ornamented with dorsal tufts, and the males possess more or less prominent anal tufts. The fore-wings are comparatively small, narrow, and crossed by a series of more or less marked crenulated or wavy lines, and with two usually darker and two paler spots in the discal part of the wing. The one nearest the base of the wing is called the orbicular; the other and larger one, usually kidney-shaped, is called the reniform spot. The hind-wings are broader, usually without markings; when at rest they are folded and concealed by the fore-wings, which lie like a flat roof over the back. The name "Owlet-moths" is

them because they fly at night, and because their rather eyes glow with a deep phosphorescence, as if internally e. Most of these moths are attracted to light, and to baits composed of fermenting substances.

The caterpillars, which average from an inch to an inch half in length, are cylindrical, tapering somewhat the middle towards each extremity; their colors are y obscure, varying from dirty-gray to dirty yellow-a, generally with feebly marked longitudinal lines.

The pupæ are usually formed in earthen cells under d, or above the same among leaves and rubbish, tied er by a few silken threads.

In a class these caterpillars are injurious to vegetation, they are frequently called "Cut-worms," because some n have the habit of cutting off the tender leaves of early in spring. Most of them are injurious to agri-e, and not a few of them cause considerable losses to culture.

THE INSCRIBED THYATIRA.

(*Thyatira scripta* Gosse).

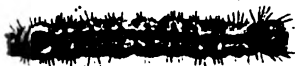
This uncommon moth has been repeatedly taken in St. ny Park and in Duluth. The caterpillar feeds on black-and raspberry; it is of a rich yellowish-brown, some-nearly black color, with a distinct black dorsal line. sides are yellowish with blackish marks and dashes. upper surface is darker than the rest of the body; the ment head is yellow, mottled with dark brown. The illar, when at rest, has the anterior and posterior por-of the body elevated, or bent in such a manner that the rests upon the posterior segments. It is not readily ed as it conceals itself in a shelter formed by bending the edge of a leaf; it pupates in moss or similar ma-

The moth is very pretty, of a pinkish-gray color, and marked in a very peculiar manner with whitish lines and blackish spots, as shown in the illustration, Fig. 151, Plate XVI.

THE GRAY DAGGER-MOTH.

(*Acronycta occidentalis* G. & R.).

There are a large number of "Dagger-moths," so called from the fact that they have on their fore-wings a number



Figs. 152 and 153 — *Acronycta occidentalis* S. & R.; moth and caterpillar.

of short, black streaks crossing the transverse lines in such a way that the marks have a remote resemblance to a dagger, or to the Greek letter *psi*, placed sideways. The above species is of a pale silvery-gray color. The fore-wings are pale gray, with various black lines and markings, the principal one being situated in about the middle resembling an irregular cross; a second smaller and similar mark is found between this and the tip of the wing; a black line starts from the base of the wing and extends to near the middle. The hind-wings are darker and glossy gray. Both pairs of wings are fringed with white, with an inner border of black spots. The moths measure with expanded wings nearly two inches across.

The caterpillars of this insect feed upon the leaves of the plum, elm, birch, cherry and apple, reaching their full size about the middle of July. Their large heads are flat in front and are black with yellowish dots on the sides. Their body is bluish-gray above, with a wide slate-colored band on the back, in which is found a central orange-colored line, extend-

ing from the second to the fifth segment. Beyond this, to the eleventh, each segment is ornamented with a group of spots, forming a dorsal band; two of these spots are orange, one in front and one behind, and one is of a greenish metallic hue; each group of spots is surrounded by a circular patch of velvety black. Two cream-colored stripes are found on the sides; they disappear towards each extremity. The body of these caterpillars is sparingly covered with whitish hairs, more prominent along the sides. A prominent hump on the twelfth segment and the feet are black. The full grown larvæ is about an inch and a half long. It spins a rather slight cocoon in some sheltered spot, in which it transforms to a polished, reddish-brown pupa. It seems as if this moth was double brooded in Minnesota. The moth and caterpillar are shown in Figs. 152 and 153.

This species is not as common as some other members of this genus of moths, and its caterpillars can readily be killed by spraying with any of the arsenical poisons.

THE MOTTLED PLUM-TREE DAGGER-MOTH.

(*Acronycta superans* Guen.).

The caterpillar of this moth feeds also on the leaves of the plum, but occurs also upon the apple, mountain ash and

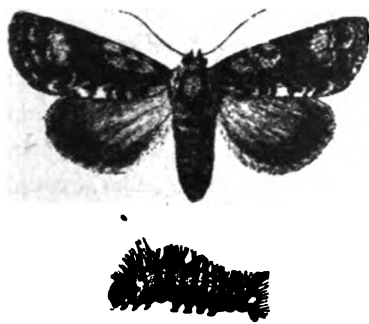


Fig. 154.—*Acronycta Superans* Gu.; moth and larva.

birch; it seems, however, as if the foliage of the shadberry was the favorite food of this insect, and it is not uncommon to see smaller plants entirely denuded on account of its presence. The larvæ are solitary in habits and appear about the middle of June and again late in September. They vary considerably in color, but are usually greenish, with a broad

chestnut-colored stripe along the back, margined with yellowish. On each segment are several shining tubercles, from each of which arise one or more blackish hairs; other hairs are found along the sides of the body. The caterpillar is about one inch long, and has the body somewhat compressed, so that it appears higher than is usually the case. It does not assume the usual position at rest as the other members of this genus which curl up somewhat in the shape of a snail. The cocoon is made among dead leaves and is a rather slight affair.

The moth has a gray thorax and abdomen, dotted with black points. The fore-wings are dark-gray, with black or brownish-black markings; the hind-wings are lighter brownish-gray. The moth expands about an inch and a half, it is illustrated in Fig. 154, as well as the caterpillar.

Only in extreme cases are these insects common enough to cause serious injury.

THE RASPBERRY DAGGER-MOTH.

(*Acronycta impressa* Walk.).

The caterpillars of this insect are always common, sometimes very much so, in which case they cause some injuries. They are very general feeders, occurring in Minnesota on the raspberry, blackberry, apple, rose, hazel, and many other plants. Although numerous the caterpillars always feed singly. They are hairy caterpillars, measuring an inch and a quarter in length when in motion, but less than an inch when at rest, as they hump their body in a peculiar manner. The body is thickest between the third and the seventh segment, and tapers a little towards both extremities; it is of a brownish-black color, with a transverse row of paler tubercles on each segment, from which spring clusters of brownish-white or grayish-hairs of varying lengths. Behind the third segment there is a space on the back where the

color of the body is plainly seen. The head is of a shining black color, the upper portion partly hidden by the overhanging hairs of the first segment. The cocoon which is tough, is made of leaves and bits of wood fastened together with silk; inside we find the brown pupa, from which emerges a gray moth, with gray fore-wings, mottled with spots, streaks and dots of darker shades of gray and black; the hind-wings are of a dull, pale gray color, deepening a little towards the outer margin. The underside of the moth is paler. With expanded wings it measures about an inch and a quarter across.



Fig. 155.—*Acronycta impressa* Walk; moth. Original.

These caterpillars are found throughout the summer, as the two generations overlap somewhat. Hand-picking and the use of arsenical poisons will keep it in check. Moth and caterpillar are shown in Fig. 155 and 134.

THE SMEARED DAGGER-MOTH.

(*Acronycta obliqua* S. & A.).

This moth does not show the usual mark of dagger-moth, hence the above rather bad sounding name was given by some writer.

This conspicuous and very beautiful caterpillar is a hairy, very brightly colored and ornamented, and about an inch and a quarter long. Its color is deep velvety black, with a transverse row of tubercles on each segment, those being bright red and set in a band of the same color,

which extends down to each side. Each tubercle gives rise to a tuft of short, stiff hairs which are red on the upper part of the body and yellowish or mixed with yellow below. Upon the back of the larva is a row of bright yellow spots, two or more on each segment; below these and close to the under surface, is a bright yellow-band, deeply indented on each segment. The spiracles are white, and there are a number of whitish dots scattered irregularly over the surface of the body.

The caterpillar of this moth feeds usually upon the willow, but is also very partial to the strawberry and rasp-

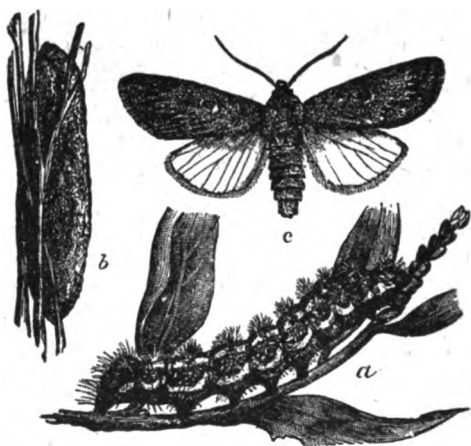


Fig. 156.—*Acronycta obliqua*. S. & A. After Riley.

berry, and is not infrequently found upon the apple and even the grape. Being often parasitized it is not likely to ever become very destructive, and as it is quite conspicuous it is readily seen. When ready to pupate it constructs a rather coarse cocoon of leaves and silk, inside of which it changes to a dark-brown pupa. We have two annual broods of this insect.

The moth is not such a gaudy looking insect as its caterpillar, but has a very modest and plain appearance. Its fore-wings are gray, with a row of blackish dots along the

hind border. The wing beyond the middle is crossed by a broken, blackish, somewhat indistinct, zigzag line; some darker grayish spots are also found about the middle of the wing. The hind wings are white. Both moth, larva, and cocoon are shown in Fig. 156.

There are a number of other dagger-moths whose larvæ are more or less destructive, being found upon the foliage of fruit trees and upon that of our small fruits. Especially the blackberry and raspberry are to the taste of such worms.

We do not very often find the larvæ of *Acronycta xilini-formis* Gn. upon the foliage of the blackberry, but we do much more frequently on the willow, rose and oak. These caterpillars possess a certain urticating power, which is located in a number of stiff and acute spines springing from warts located on the back. Even the common caterpillar of *Acronycta americana*, so numerous upon such shade trees as maples, etc., although covered apparently with long and soft hairs, can cause considerable irritation upon a soft and tender skin, and the writer has seen the greatly inflamed neck of a boy upon which one of these caterpillars had been pressed by the collar of the vest or coat. This urticating effect seems to be simply a mechanical one, and not one caused by the presence of any special acid.

A. furcifera, *A. fragilis*, *A. lithopsila*, *A. funeralis*, *A. tritona*, *A. falcula*, *A. grisea*, *A. luteicoma*, *A. morula*, and *A. hamamelis* all occur in our state and are all known to feed to some extent upon the leaves of fruit-producing plants.

THE PALSIED CATERPILLAR.

(*Harrisimemna trisignata* Walk.).

There are few caterpillars that possess such a peculiar shape, or have such alarming habits as this one, which is frequently found upon the foliage of ash, willow, lilac and

the apple. Persons not familiar with such harmless beings as caterpillars are apt to call this one a most hideous looking object, especially if they happen to disturb it ever so slightly; in this case the worm will raise the front part of the body back to the abdominal feet, and thresh it violently from side to side, in fact, its head shakes nearly all the time, like a person with the palsy. To heighten the effect the caterpillar carries a string of cast heads upon some very long and stiff hairs just behind the head. The caterpillar has head and adjoining segment black; segments 3 and 4 yellow with black points; segments 5, 6, and 7 are brown varied with white and 8, 9 and 10 are white, 11, 12 and 13 are brownish-black. The body is very deeply incised between the segments, and the abdominal feet are long, especially the first two pairs. Segments 6 and 12 are much produced dorsally, being very pointed; this, together with the habit of arching the body between the anterior feet and the long abdominal ones, causes it to present a very irregular and jagged outline. The caterpillar eats a hole of the diameter of its body into soft wood, and in it changes to a pupa.

The moth is one of the most distinct and striking ones of all North American noctuids, possessing three round and brown patches on each wing.

The insect is not common enough to cause much injury.

All the noctuid mentioned thus far resemble bombycid caterpillars, being hairy, even possessing pencils and tufts of hairs, and spinning a cocoon. Most of the noctuid caterpillars described hereafter are genuine noctuid caterpillars, and are frequently called "Cut-worms."

Most cut-worms hide in the ground during the day and do not commence to feed until night, when low-growing plants are attacked. Some, however, have developed a climbing tendency, and make their way upon trees and shrubs to eat the young shoots and buds. Whenever such climbing cut-worms are at all numerous in our orchards and fruit-gardens they can cause great destruction, and we

have cases on record where they did more damage than any other insect enemy. Being nocturnal they are not often seen, but if the reader will go out some night early in spring, and beat with a stick the twigs of fruit-trees over an inverted umbrella, he will have no trouble in finding more worms than he likes to see. The writer has in this way beaten from a single small apple-tree as many as 100 cut-worms, which accounted for the fact that these trees did not seem to do as well as they ought to. During the day these cut-worms hide in the ground near the tree. As a general rule large numbers of them can be killed by the use of poisoned baits made of bran, Paris-green, water and a little sugar or molasses. These baits are placed near the tree, and will almost invariably attract and kill the majority of such worms. Other baits made of wilted plants and Paris-green are also of great use.

It would take too much space to describe the large number of cut-worms that can be found upon our fruit-producing plants, and only a few will be given; the habits of all are essentially alike.

THE GREASY CUT-WORM.

(*Agrotis ypsilon* Rott.).

This is one of our most abundant cut-worms which attacks all sorts of garden products and other low-growing plants; it is frequently quite destructive to the strawberry beds. When full grown it is about an inch and a half long, dull brown, inclined to black, with paler longitudinal lines, and a faint broken yellowish-white line along the back, and two other indistinct pale lines on each side. The moth is readily recognized by the ypsilon-shaped mark upon the forewings, which are brownish-gray

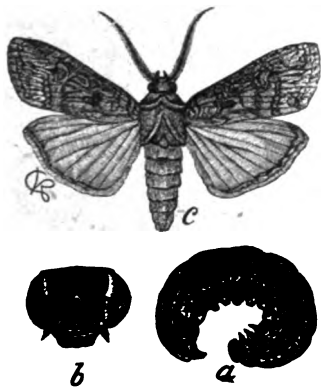


Fig. 157.—*Agrotis ypsilon* Rott.
After Riley.

with darker markings; the hind-wings are almost white and semi-transparent, and possess a pearly lustre. Both caterpillar and moth are shown in Fig. 157.

THE VARIEGATED CUT-WORM.

(*Peridroma saucia* Hub.).

We quite often find a large number of eggs, of a pinkish color, round and flattened, deposited side by side on the twigs and leaves of the apple and cherry. These eggs hatch into small dull-yellowish worms with darker spots. The mature caterpillar is of a dull flesh-color, mottled with brown and black, and with elongated velvety-black markings on each side. This is one of the most voracious of all cut-worms, and may be found at almost any time during the season hidden in the ground near some plant. After reaching a length of about two inches it enters the ground to form there an oval and smooth cavity in which it changes to a deep mahogany-brown pupa.

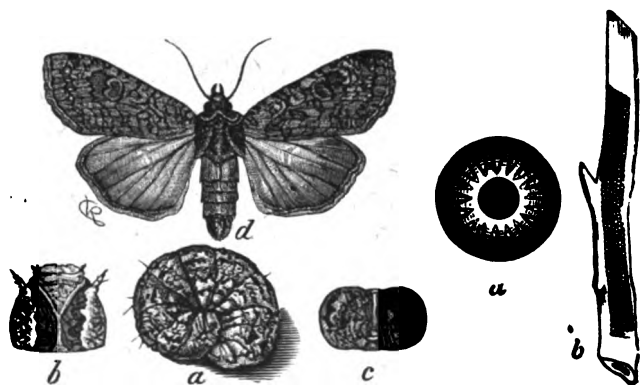


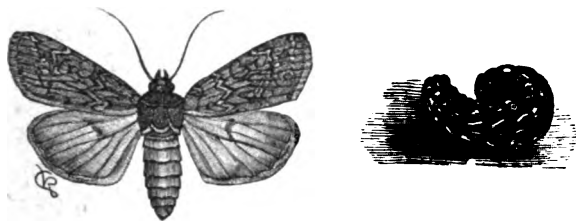
Fig. 158.—*Peridroma saucia* Hub. After Riley.

The moth, which expands about an inch and three quarters across, has grayish-brown fore-wings, marked with brownish-black; the hind-wings are pearly white, shaded towards the margin with pale-brown. The caterpillar, eggs and moth are illustrated in Fig. 158.

THE "W" MARKED CUT-WORM.

(*Noctua clandestina* Harr.).

This caterpillar is also found upon the foliage of the
e and currant. In some seasons it damages seriously the

Fig. 159.—*Noctua clandestina* Harr.

e-buds, though it usually prefers such plants as corn, cab-
, etc. Both caterpillar and moth are shown in Fig. 159.

THE CLIMBING CUT-WORM.

(*Carneades scandens* Ril.).

This cut-worm is a very active climber and causes great
s to the nurseries and orchards. The caterpillar (Fig.

Fig. 160.—*Carneades scandens* Ril., caterpillar.

160) is of a light yel-
lowish-gray color, var-
iegated with dull green;
with a dark line down
the back and fainter
along the sides; the spiracles are dark, as are the cervical
-shields. It reaches a length of nearly an inch and a half
when it enters the ground and changes to a brown pupa,
which in time emerges the moth, which is of a light
r, the fore-wings being light bluish-gray, with darker
kings, and the hind-wings pearly white. This cut-worm
very common in Minnesota, and sometimes almost en-
y destroys the very young foliage of our white and over-
oaks. The moth is shown in Fig. 160, plate VIII.

The STRIPED CUT-WORM (*Feltia jaculifera* Gn.), the
CKERED RUSTIC (*Carneades tessellata* Harr.), the ER-
C ARMY-WORM (*Noctua fennica* Tausch), and a number

of other cut-worms are only too frequent visitors to our gardens, and are never slow in devouring the foliage of the strawberry and other low-growing plants. They are always very destructive in nurseries, and not seldom enter the greenhouses, where they can cause great havoc amongst tender plants.

The use of poisoned baits against cut-worms has already been given; it can, of course, be employed against all kinds, including the climbing ones. One of the most effective remedies against the latter is to fasten strips of tin around the tree, cut in such a way as to form, when fastened to the trunk, a sort of inverted funnel. Many worms can be collected after dark by jarring the trees over sheets spread on the ground. The writer uses with very good results a large inverted umbrella, the inside of which is lined with some material like that used in the Turkish or bath-towels; this absorbent material is soaked with kerosene, and all insects that drop in the umbrella must come in contact with the oil and are

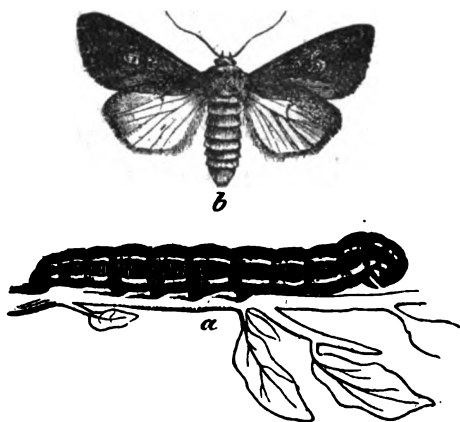


Fig. 161.—*Mamestra picta* Harr. From Div. of Entomology, Dep. of Agriculture.

doomed to die. In this manner large numbers of various kinds of insects can be beaten from the trees into the inverted umbrella and then destroyed. If very many trees have to be protected against the ravages of these and allied in-

It is of course best to spray them with Paris-green or iron-purple, in the proportion of a teaspoonful to a full of water, to which should be added some lime-water to neutralize any free acid. In Germany the foresters protect trees by the use of "Raupenleim" or dendrolene; this is a sticky material painted in a ring or band around the trunk of the tree and which prevents the worms from ascending. A thick layer of fluffy cotton-batting, tied at the bottom and rolled over to form a cone, is a good substitute for the Raupenleim, which can, however, now be bought in the United States.

There are other genera of cut-worms which are injurious to fruit and fruit trees. *Mamestra confusa* Hub. has been found feeding upon the foliage of apples; so has *M. assimilis* L., and even *M. picta* Harr., the Common Zebra-caterpillar of the Cabbage (Fig. 161) is not averse to eating apple leaves.

THE GLASSY CUT-WORM.

(*Hadena devastatrix* Brace).

This insect belongs to another genus of cut-worms. The glassy-looking caterpillar is of a shining pale-greenish color,

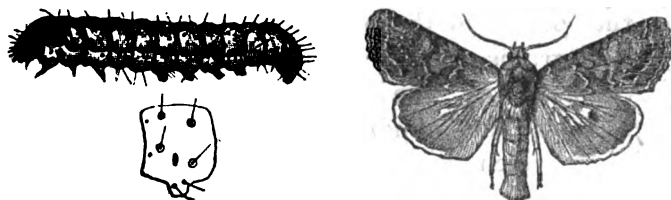


Fig. 162.—*Hadena devastatrix* Brace. After Riley.

It has a brownish-red head and a dark brown and horny shield. It has on each ring a number of shining tubercles, from which arise single hairs. The ashen-gray moth is marked with black and white spots, streaks and dots; the hind-wings are pale and brownish-gray.

These caterpillars are very destructive to the strawberry, as they not simply eat the leaves but cut through the base of the plant, leaving it to wilt. It is not easy to destroy this insect, although the free use of arsenical poisons will have some good effect. All plants that are seen to wilt suddenly should be closely investigated, and with a little attention the culprit will be found in the ground within a few inches of the infested plant. It is illustrated in Fig. 162.

THE FALL ARMY-WORM.

(*Laphygma frugiperda* Guen.).

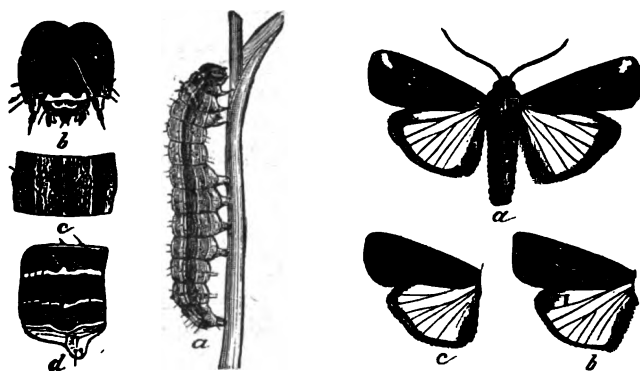


Fig. 163.—*Laphygma frugiperda* Guen. After Riley.

This insect has been repeatedly found in its larval state upon the foliage of the apple tree, though its usual food-plants are grains and grasses; it seems to be, however, a very general feeder. The eggs, which are deposited in small clusters, were also found upon the apple, and the young caterpillars which hatched from them were fed with the leaves of that tree, and they seemed to enjoy this food. There is, however, little danger that this species will ever become destructive to our orchards, but it will always be more or less injurious to our small grains. It seems to have many enemies amongst parasitic insects, otherwise the insect would be very much more common than it is. The moth, which varies greatly, and the caterpillar are shown in Fig. 163.

THE CHAMYRIS.

(*Chamyris cerintha* Tr.).

This beautiful moth, shown in Fig. 164, Plate VIII, feeds as a caterpillar upon the leaves of apple, plum, rose and other plants, but is not common enough to cause much damage.

PYRAMID GRAPE-VINE CATERPILLAR.

(*Amphipyra pyramidoides* Guen.).

This is a very common insect, which gathers in large numbers about baits made of fermenting substances; many of the moths are found also late in the season hiding under the bark in the woods. Yet notwithstanding that the moth is very common the fine looking caterpillars are not so readily seen, since they either hide during the day or re-

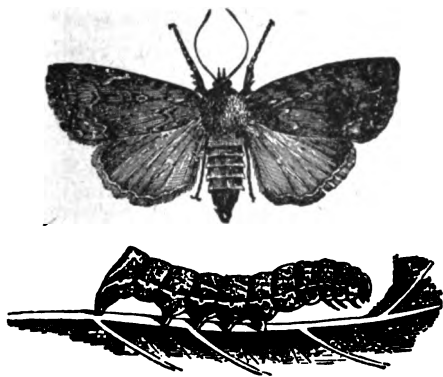


Fig. 165.—*Amphipyra pyramidoides* Gu. After Riley.

hide so closely the foliage among which they are feeding that they are not readily detected. But the effect of their hungry mouths is sometimes plainly visible upon the leaves of grape-vine, raspberry, strawberry and other cultivated and wild plants. The caterpillar is nearly an inch and

a half long, naked, tapering towards the front and thickened behind. It has a small head, whitish-green in color, with the powerful mandibles tipped with black; the body is also whitish-green, a little darker on the sides, with a white stripe on the back, widening behind and slightly broken between the segments. A bright yellow stripe occurs on each side and a second one of the same color, but fainter, half way between this and one on the back, which is more distinct posteriorly and which follows the peculiar prominence on the twelfth segment. The underside of the body is pale-green. As soon as mature the caterpillar descends to the ground, where it draws together some old leaves or similar material, among which it spins a slight cocoon, inside of which it changes to a dark-brown pupa, from which the adult insect escapes the latter part of July or early in August.

The moth is a large and rather heavy insect, measuring across the wings about one and three-quarter inches. The fore-wings, which have a peculiar silky lustre, are dark brown, shaded with paler brown and with dots and wavy lines of dull white: the hind-wings are reddish with a coppery lustre, becoming brown on the outer angle of the front edge of the wing and paler towards the hinder and inner angle. The under surface of the wings is much paler than the upper. The body is dark brown; the rings have a pale border. Both moth and caterpillar are shown in Fig. 165.

THE SILKY PYROPHILA.

(*Pyrophila tragopoginis* Linn.).

Only a single specimen of this interesting moth has been captured, in Rochester, Minn. Its caterpillar feeds upon the grape, and occurs in the Eastern States in sufficient numbers to become a source of annoyance. According to Saunders the caterpillar of this moth is of a yellowish-green color, with a very few fine brownish hairs scattered over the upper

of its body. It attains its full growth about the middle of June, when it measures an inch and a quarter or more in length. The head is small, green, the jaws tipped with brown; the surface of the body is yellowish-green, a little darker between the joints; there is a white stripe down the middle and two of the same color along each side, the lowest being most distinct. On each segment there are several small white dots, from each of which arises a single fine hair. The under side is deeper in color than the upper. When mature it changes a little under the surface of the ground to a subterranean chrysalis, from which the perfect insect escapes in about two weeks.

The adult moth measures, when its wings are spread, about an inch and a quarter across. Its fore-wings are grayish-brown, with a silky lustre, with several pale dots on the outer edge, and three short dark streaks near the middle. The hind-wings are paler.

When found to be injurious the caterpillars may be subdued by hand-picking or by the use of arsenical poisons.

THE STALK BORER.

(*Gortyna nitela* Gu.).

In 1898 the caterpillars of this insect were very common and injurious in Minnesota. They not only destroyed much of the straw in many places, but also caused great injury to the leaves of raspberries and blackberries, which they hollowed out so that the infested parts of the plants wilted (see Plate XXIII). They also bored in the stems of the potato, spinach, aster and others, and even twigs of the trees did not escape. The worms devoured in some cases the fruit of the strawberry. Besides useful plants, many others were destroyed by these voracious feeders.

As long as the caterpillars are still young they are of a pale green with bright stripes along the body, the one on the

side being interrupted towards the head. When the larva has reached its full size it leaves the cane, etc. which it had occupied and descends a little below the surface of the ground, where it transforms to a brown pupa, from which the moth emerges from about the end of August to the



Fig. 167.—*Gortyna nitela* Gu. From Div. of Entomology, Dep. of Agriculture.

middle of September. The moth is of a general mouse-gray color, with a light band on each fore-wing. It, and the caterpillar, is shown in Fig. 167.

There is no known remedy for these insects in the fields; in case the plant infested in an orchard is a valuable one we have to remove the caterpillar with the knife.

THE WHITE-DOTTED APPLE-WORM.

(*Nolaphana malana* Fitch).

This moth (Figs. 168 and 169, Plate VIII.) is fairly common in Minnesota, although its larva was not observed upon the tree it infests until the last season, when late in



Fig. 168—*Nolaphana malana* Fitch.

autumn it was so numerous in some isolated cases as even to cause some injury. The worms were found of nearly all sizes as late as September 15th, eating regular notches in the margins and holes in the middle of the leaves of the apple.

Each caterpillar feeds alone, and is well hidden on the under side of the leaf, which is usually somewhat bent and hollow. It is a rather thick, cylindrical, light whitish-green worm,

h numerous whitish dots. On reaching maturity the
va selects a leaf and drawing together a portion of it
h silken threads forms a sort of hollow tube. In this it
kes a very slight silky cocoon, inside of which it trans-
ns to a brown chrysalis. We seem to have two annual
ods, the last one of which winters in the pupal stage.
e caterpillar is shown in Fig. 170, Plate XIX.

The small moth, which expands only three-quarters of an
n or a little more across, has fore-wings of an ashy-gray
or, which are whitish towards the margin, crossed by
ee irregular, black lines, which are faint and indistinct
wards the inner edge; near the middle of the wing there is
quently a round and whitish spot with a black dot in the
ter. The hind-wings are dull whitish, dusky towards the
s. Beneath both wings are of a silvery-whitish hue,
inkled with blackish dots towards the outer edges.

These caterpillars feed on the cherry, plum, elm, poplar
d other trees, but seem to be partial to the apple and
dberry.

THE UNIFORM WHITE-SPOTTED SCOPELOSOMA.

(*Scopelosoma sidus* Gu.).

This is one of our very earliest moths, examples having
n caught as early as March 15th. The moths are readily
racted to sugar baits, and come in large numbers until
ut the middle of April, when they gradually disappear.
captivity they readily deposit yellowish-white eggs, per-
ly globular, and ornamented with numerous fine ridges.
ore the eggs hatch they change to a light brownish color.
e caterpillars have a bright honey-yellow head, and the
vical-shield, which is very prominent, is polished black.
e thoracic and first abdominal segments are brownish,
d dorsal space is light green or whitish, with the median
e and subdorsal stripe white; a brown line above the

stigmata and a broad, white, lateral line are also seen. The under side is light green. All the piliferous warts are prominent, black, and bear a short fine hair. As soon as mature, which takes place about the middle of May, the larvæ enter the ground in which they pupate. Some of the moths issue from the last of September to the early part of November, and seek shelter under loose bark and other suitable places; other pupæ remain in the ground until the next spring.

The moths are rather uniformly brown with a few more or less distinct wavy lines of gray or grayish-white. Most of them have in the middle of the fore-wings a perfectly white spot, which is, however, in some cases colored very lightly with brownish. It is shown in Fig. 170½, Plate XXIII.

A number of other species of the genus *Scopelosoma* fly at the same time; they have identical habits and their caterpillars are all very similar. They are very general feeders, and as they hatch in most cases before there are any leaves they attack the leaf-buds of oak, cherry, apple, raspberry and blackberry. If numerous they can cause some damage. A single application of London purple will prevent any further injury.

THE ASH-GRAY PINION.

(*Xylina antennata* Walk.).

The caterpillars of this moth are also very general feeders, but as they have the bad habit of boring into young apples and of eating the foliage of that tree, of the hickory and other trees, it is best to describe them in this place. As far as the habits of this insect are concerned they are very similar to those of the one just given. The moths appear also very late in the year and quite early in the following one, having been captured in large numbers in April. The

own caterpillar is pale green, with cream-colored
and a broad, cream-colored lateral band along the
The large head is glassy-green with white mottlings

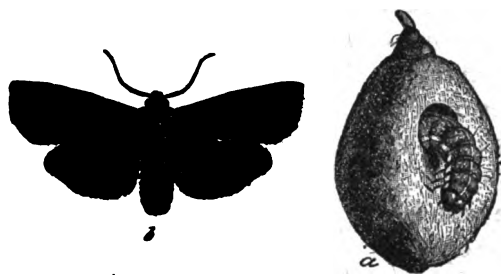


Fig. 172.—*Xylina antennata* Walk. From Div. of Entomology,
Dep. of Agriculture.

and top, and pearly-white lips; the legs are whitish;
legs concolorous with the under side of the caterpil-
which is a glaucous-gray. When the caterpillar has
a length of about one inch and a fourth it is full
and now enters the ground in which it forms a very
cocoon of silken threads, inside of which it changes
mahogany-brown pupa. Fig. 172 shows moth and
larlar.

The moth is of a dull ash-gray color; the fore-wings
iegated with darker gray or grayish-brown. When
the wings are folded lengthwise and appear almost
l and like a flattened roof, giving the insect an
ce appearance.

BETHUNE'S XYLINA.

(*Xylina Bethunei* G. & R.).

s moth is found in large numbers with the preceeding
d as it feeds in its larval stage upon the same useful
it is here mentioned. The moth is very different in
ion, though otherwise like *antennata*. The color
greatly, some moths being almost white, or brownish-
with slightly darker markings, while others are much

darker, with quite dark brown markings, which obscure the lighter ground-color. The under wings also vary in intensity of color, some being almost cream-white, while others are decidedly dusky. A moth is shown in Fig. 173, Plate XXIII.

The life-history of this insect is almost identical with that of *antennata*.

A number of other species of this genus fly at the same time, and as they are sometimes very numerous they must cause some injury. The caterpillars of *X. devia* and of *X. ferralis* have been bred in captivity not alone upon oak but also upon the apple.

THE PLUM-TREE CATACOLA.

(*Catocola ultronia* Hub.).

In the large family of noctuid moths few are better known and more admired than the moths forming the extensive genus *Catocola*. As far as the collector of moths and butterflies is concerned these insects are his pets. The members of this genus are medium or quite large moths, with very bright colored hind-wings, which are banded with black, yellow, red, or white; even the blue color occurs in a German species, where the moths are known by the name of "Ordensbänder." Their fore-wings are mottled with various colors and look like bark. They rest exposed during the day upon the trunks of trees, entirely invisible because they thoroughly blend with their surroundings and having the bright-colored under-wings entirely covered with the upper ones. The moths seem to know how the surface of their fore-wings is marked and colored, since, if disturbed, they fly off very rapidly to some other tree, and circling around it they do not settle unless it offers spots matching these colors.

The caterpillars of the moths under consideration are very curious beings, which resemble those of the lappet-

has already described. The leech-like caterpillar (Fig.) is flattened, having the body thick in the middle and tapering towards each end. It is of a grayish-brown color, like the bark upon which it hides while resting. When full grown it is a little longer than an inch and a half, is dull grayish-brown above, with two or four small reddish circles on each segment of the body, all encircled by a light ring of black at their base. On the upper part of the eighth segment is a stout and fleshy horn about one-twelfth of an inch long, pointed, and similar in color to the body,

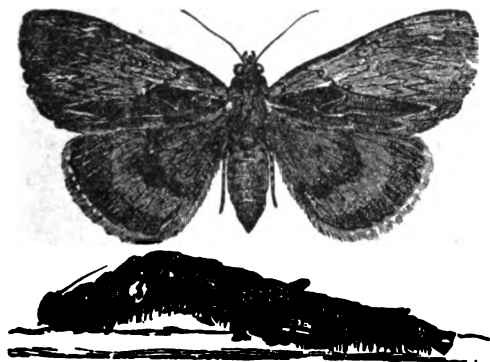


Fig. 174.—*Catacula ultronia* Hub.

with an irregular grayish patch on each side. On the eighth segment there is a low, fleshy ridge, tinted behind with deep reddish-brown; there is also an oblique stripe on the eighth segment of the same color extending forward.

Along the sides of the body, and close to the under surface, there is a thick fringe of short, fleshy looking hairs of a pale pink color. The under side is also pink, deeper in color along the middle, with a central row of nearly round black spots, which are largest from the seventh to the eighth segment.

These caterpillars are not uncommon; they prefer the bark of the plum-trees, upon which tree they sometimes occur in large but never in destructive numbers. When the

caterpillar has reached its full size towards the end of June it descends to the ground, where under some dead leaves it makes a very flimsy cocoon of silk, inside of which it changes to a brown pupa, which is densely covered with a peculiar bluish flour-like substance that rubs off very readily.

The beautiful moth, shown in Fig. 174 and in Fig. 175, Plate XXIV, has the fore-wings of a rich amber color, darkest on the hind-margin, with a broad diffused ash-colored band along the middle, not extending to the apex, which is brown. Several brown and white zigzag lines cross the wings. The hind-wings, usually so dull colored in Owlet-moths, are deep red, with a wide black band along the outer margin and a narrower one of the same color across the middle.

The moth deposits her eggs, which are well hidden in the cracks of bark, during July and August.

THE APPLE-TREE CATACOLA.

(*Catacula grynea* Cram.).

This is another species found rather abundantly in Minnesota. The moth is not as brightly colored as the one described before, but is also a very fine insect. Its fore-wings are uniformly grayish-brown, marked with zigzag lines of rich brown and gray, and with a number of very dark-brown short streaks on the anterior margin. The under-wings are reddish-yellow, margined with lighter reddish-yellow, and crossed by two wavy black bands. It is shown in Fig. 176, Plate XXIV.

The caterpillar is ashen-brown with a reddish cast. An indistinct light-colored dorsal line and two or three indistinct lateral light-colored stripes distinguish it. On the dorsal space is a row of small prickles, of which those on the posterior part of each segment are the largest. There are three small points on the sides of each segment arranged in

form of a triangle. On the top of segment eight there is a projection, sometimes of a redder color than the body. The upper side is light colored, sometimes tinged with red, marked with a row of black spots, one to each segment. The head, bilobed at top, is reddish or grayish-ash, frequently bordered on the top and sides with black. When grown the caterpillars measure one and a quarter inches in length; it now forms a cocoon among dead leaves.

The two anterior pairs of abdominal legs are much smaller in the caterpillar of this genus of moths than the posterior pairs, hence they possess a looping gait.

There are other species of *Catacola*, the caterpillars of which occur upon the foliage of fruit trees, but as the life-histories of all are very similar it is not necessary to mention them. At all events they do not occur in sufficient numbers to cause much injury. A much larger species found on apple is *C. paleogama* Gu., on Plate XXIV, Fig. 177.

FAMILY GEOMETRIDÆ OR SPAN-WORMS, LOOPERS OR MEASURING-WORMS.

There is not much difficulty in recognizing these insects. The moths possess slender bodies, small heads, and very broad, frail and thin wings. The hind-wings are usually much more ornamented as the fore-wings, so that the lines of the one pair are often continued across the other. The hind-wings are not hidden at rest, but all four wings are fully extended in most cases, although exceptions occur. The caterpillars lack all save one or at most two pairs of thoracic or abdominal unjointed legs, and in moving they first extend the body to its full length, then bring the posterior end of it close to the front legs, looping the body in the process, then stretch out again and repeat the action. This peculiar motion has given them the names of Span-worms or Measuring-worms, as well as their scientific name *Geo-*

metridæ. Prof. Comstock describes these worms and their very characteristic actions in this way: "As children we had the dislike for 'worms' that is common to people that are uneducated to the beauties of nature. All larvæ were 'worms,' and we never thought of admiring their beautiful colors, or of watching them build interesting houses, or of keeping them until they spun their silken cocoons. But the measuring-worms were excepted from this dislike. We always found these delicate, greenish or yellowish caterpillars with their looping motion vastly interesting. We allowed them to measure our fingers with their little tickling feet, and we counted each length as a yard. We were always delighted with the way they had of standing on their hind legs, rearing the body up into the air, and moving the head around as if looking at the scenery. And then, if one became frightened in any way, it would drop suddenly, suspended by a silken cord, which it had mysteriously concealed in its mouth; and down it would go, doubling and whirling around and around frantically until it reached the ground."

THE SNOW-WHITE EUGONIA.

(*Ennomos subsignarius* Hbn.).

This is a very common moth, which has long been known as destructive to shade trees, and especially to the elm and linden. But its caterpillar feeds also upon the foliage of the apple, and in the south this insect has been quite destructive from time to time.

The moth is pure white, spreading about an inch and a half across. The sexes differ in the antennæ which are strongly pectinated and toothed in the male and but slightly so in the female. The latter deposits a large number of smooth irregularly ovoid eggs, slightly flattened on the sides, rounded at the bottom, with a depressed top with a whitish rim or edge, which forms a perfect oval ring. Many

eds of eggs are deposited in rows on the underside of
 lbs, frequently near the very tops of the trees.
 The dark-brown caterpillar has the large head and ter
 segment of a red color.

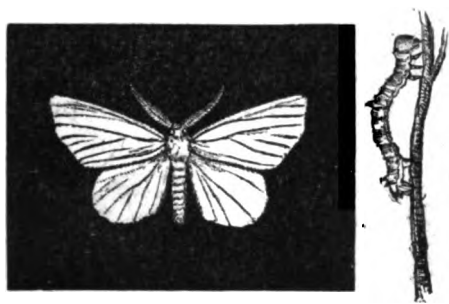


Fig. 178.—*Bugonia subsignaria* Hbn. From Div. of Entomology,
 Dep. of Agriculture.

Whenever this insect becomes as numerous as it is
 in some regions, where its caterpillars devour the leaves of
 every kind of tree, bush or shrub, we should spray
 infested trees with Paris green or London purple.
 The moth and caterpillar are shown in Fig. 178.

THE CURRANT ENDROPIA.

(*Endropia armataria* H. S.).

This is not a common insect, hence not injurious at pres-
 ent it has been found several times in rather large num-
 bers upon the black currant, the leaves of which are eaten
 by the larvæ. It also eats the foliage of the red currant. We
 during July small and nearly black measuring-worms
 on the leaves of this plant; the worms are spotted with
 yellow, and have a series of crescent-shaped spots on
 their back and a row of raised dark-brown dots along each
 side, those on the posterior segment being tipped with yel-
 low while on the last segment there is a fleshy hump or
 prominence composed of two round tubercles. This cater-

pillar reaches a length of three-quarters of an inch, when it constructs a slight web, interwoven with bits of dead leaves and other rubbish. Inside this cocoon it changes to a brown pupa which does not produce the winged insect until June of the following year.

The small moth is a rather pretty insect, having the wings, and especially the hind ones, deeply indented. The wings are yellowish-brown, shaded with purple, especially



Fig. 179.—*Endropia armataria* H. S.

on the hind-wings, and with streaks and dots of a deeper shade of brown. The lower surface of the wings is deep-yellow dotted and streaked with reddish-brown. Two moths are shown in Fig. 179.

THE CURRANT ANGERONA.

(*Angerona crocataria* Fab.).

The moth of this insect is quite numerous, and may be frequently seen flying about, especially if we flush it by walking in open woods or wherever the wild currant, gooseberry and strawberry are found in abundance. It is a bright-colored insect, varying greatly in intensity of colors and markings of wings. The usual color is sulphur-yellow, more or less intense, marked with brownish or dusky spots, which are sometimes very numerous, while in other examples they are almost absent. In well-marked examples they form an imperfect band across the wings. The underside of the insect is usually a little deeper in color than the upper one. With expanded wings the moths measure nearly an inch and a half across.

caterpillar, a little longer than one inch and a half in nature, is a typical spanning—or measuring—worm, tapering considerably towards the front. It is of a yellowish-green color, with an indistinct whitish line down the back, and a rather broad whitish streak on each side below the spiracles, bordered above with faint purple, which increases in depth of color on the posterior segments and becomes a purple stripe on the last one. The spiracles are white, edged with purple; each segment of the body has the anterior portion swollen and yellowish. On most of the segments are a few minute black



Fig. 180.—*Angerona crocataria* Fab.

The caterpillar forms a slight cocoon inside the space of the edges of which have been drawn together for this purpose. The pupa is of a dark olive-green color, with a yellowish abdomen and a row of black dots down the back and another one on each side. The imago appears in about a fortnight; it is shown in Fig 180.

Being a general feeder, the insect, though quite common, does not often occur in sufficient numbers on cultivated plants to become destructive. Yet the writer has seen cases where large patches of currants had lost their entire foliage because of these worms. In fact we can never say with assurance that an insect of this kind will not most unexpectedly and suddenly multiply to such an extent that it becomes a veritable pest. Another geometer, usually very common, in fact almost unknown, became so destructive in 1888 as to defoliate the wild gooseberry plants over twenty square miles. It is the *Diastictis* (*Thamnonoma*) *viridis* Pack. As the moths vary considerably a number of them are shown in Fig. 181, Plate XVIII.

THE THREAD-BEARING SPAN-WORM.

(*Microgonia limbaria* Haw.).

This moth, formerly called *Nematocampa filamentaria*, is produced from a very singular caterpillar, which is not uncommonly found upon the plum, apple, crab-apple, oak, hazel, strawberry and other plants, showing that it is a very general feeder. It measures not quite an inch in length, is of a grayish color, with dusky and blackish streaks, and bears on the posterior part of the fifth and sixth segments a pair of long, curved and fleshy horns, two of which extend forward and two curve backward (Fig. 182). The head is

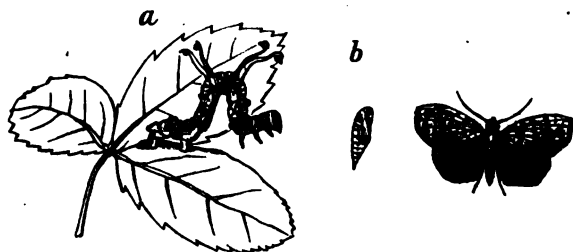


Fig. 182.—*Microgonia limbaria* Haw. From Div. of Entomology, Dep. of Agriculture.

brown, and there are two short brown tubercles on the posterior part of the fourth segment, and two small gray warts on each of the segments behind, those on the eleventh being most prominent. As soon as this queer-looking insect has reached its full size it constructs a slight silken cocoon, composed of pieces of leaves fastened together with silken threads, and inside this shelter it changes to a reddish-gray or pale-brown pupa. About ten days later the perfect insect escapes.

This is a small moth of a pale ochreous color, marked with reddish-brown lines and dots, with a ring on the discal space, just beyond which is a dark lead-colored band, which becomes an almost square patch on the inner angle, and is continuous with a broad band of the same color on the

ings. The moths which fly during July and early August, measure a little less than an inch across. As they are numerous enough to cause much injury no special remedies are given.

THE RASPBERRY GEOMETER.

(*Synchlora glaucaria* Gn.).

This is a very delicate moth, less than half an inch across. Its wings are of a pale green color, crossed by two or three darker bands of a lighter shade. Its body is green above and white below. The moth is quite abundant, and can be seen fly about if we walk through fields in which grow patches of raspberry plants upon which it feeds. It seems that the cater-

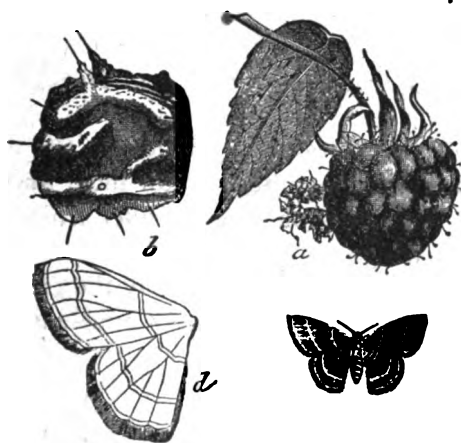


Fig. 183.—*Synchlora glaucaria* Gn. a, caterpillar; b, one segment of same; c, wings enlarged. After Riley.

prefers to eat the ripe berry, and that it does not care much for the foliage, for which taste it surely can not stand. At all events the caterpillars reach their full size at the time that the raspberry ripens. They measure at the time about three-quarters of an inch in length, are of a greenish-gray color, and each segment is furnished with sev-

eral short prickles. Like some closely allied caterpillars this one has the habit of disguising itself by attaching to the thorny prickles upon its body tiny bits of vegetable matter, such as the anthers of flowers, and by this means it often escapes detection. It makes a slight cocoon, and changes to a pupa of a yellow color with darker lines and spots, from which soon afterward emerges the perfect insect. The different states of this insect are shown in Fig. 183.

Besides the raspberry, the caterpillar also occurs upon the fruit of the blackberry.

It is not likely that this insect will ever become very destructive. If it does we can not depend upon any poisonous insecticides, as otherwise the fruit could not be used, but have to resort to hand-picking.

THE ABORTIVE DYSPTERIS.

(*Dyspteris abortivaria* H. S.).

This green moth is closely allied to the *Synchlora*. It expands about seven-eighths of an inch, and is of a pale-green color, with two oblique parallel white lines running through both wings. The moth can be recognized at once from all other similar colored ones by the great difference in size existing between the fore and hind-wings, the former



Fig. 184.—*Dyspteris abortivaria*
H. S.



Fig. 184½.—*Eumacaria bruneraria* Pack.

being rather large, while the latter are not more than half as large as might be expected when compared with other moths of the same genus. The moth is not very common. It is shown in Fig. 184.

The green caterpillar is stated to feed upon the leaves of apples, one of which is rolled up by it and thus forms a shelter. It reaches its full size early in August, when it descends to the ground and where it transforms to a pupa among the rubbish found there.

THE PLUM GEOMETER.

(*Eumacaria brunnearia* Pack.).

The caterpillars of this beautiful geometer feed upon the leaves of the wild red cherry, but occur also upon plum and apple trees. They are nearly an inch long when they reach their full size towards the middle of July; their color is dull black red, resembling very closely that of the bark upon which they rest. Their head is dark red, almost black, with white sutures; the longitudinal stripes usually found upon the sides of such caterpillars are simply represented by faint white lines; spots of the same color occur also upon the sides. The round spiracles are situated on small black circular marks. The caterpillars vary considerably both in colors and markings. At rest they are very difficult to detect, as they hold on only by their prolegs, their cylindrical, smooth and uniform body standing out like a short branch; sometimes they hold on to a leaf by their fore-legs, making their prolegs appear like petioles. They descend to the ground in autumn and transform to rather stout dark brown pupæ with a rounded and smooth front; the last segment ends in a slender long spine with terminal hooklets. The pupa, which is not protected by a cocoon, remains in the ground over winter.

The moth is of a uniform brown color with but few markings. On the fore-wings are three transverse dark brown lines; the hind-wings are somewhat paler and more uniform with two distinct dark lines. The moth expands to about one inch across the wings. (Fig. 184½.)

THE VESTAL CORYCIA.

(*Corycia vestaliata* Guen.).

This delicate moth is snow-white, iridescent, with no markings; the long fringes are also white, as is the front of the head; the palpi are yellowish on the outer half, and the antennæ, which are white above, are sometimes brownish, and yellowish beneath. Brown stains occur along the under side of the costa of the fore-wings, as far as the apex. This moth has an expanse of wings of nearly one inch.

The caterpillar is stated to feed upon the foliage of the apple, but has not been seen, though the moth is fairly common.

THE CURRANT SPAN-WORM.

(*Eufitchia ribearia* Fitch).

The caterpillar of this rather common insect is quite destructive to the black currant and the gooseberry. It transforms into a moth which is frequently flushed while walking in places where wild currant and gooseberry bushes grow. The caterpillar, which measures when full grown a little more than an inch, is of a whitish color, with a wide yellow stripe down the back, another of the same character along each side, and a number of black spots of different sizes upon each segment. The under side is white, with a slight tinge of pink; it is also spotted with black, and has a wide yellow stripe down the middle. This brightly colored caterpillar resembles somewhat that of the European Harlequin caterpillar, and can become equally destructive to the gooseberry. Happily there is but one annual generation of this insect. When these caterpillars are disturbed they let themselves down very suddenly by means of a silken thread, and remain suspended in mid-air, or until the danger is past, when they reascend in the peculiar way called by sailors "hand over

d." This habit of lowering itself and remaining suspended can be utilized in the following manner to destroy large numbers of such insects: after striking the bush, a red stick is passed all around under it and in this way all hanging threads may be caught, and the caterpillars run out in groups and crushed with the foot.

The moth is of a pale yellowish color, with several brownish spots, which vary considerably in size and form, being prominent in some examples, where they may even form one or two irregular bands across the wings. The moth measures about an inch and a quarter across. Soon

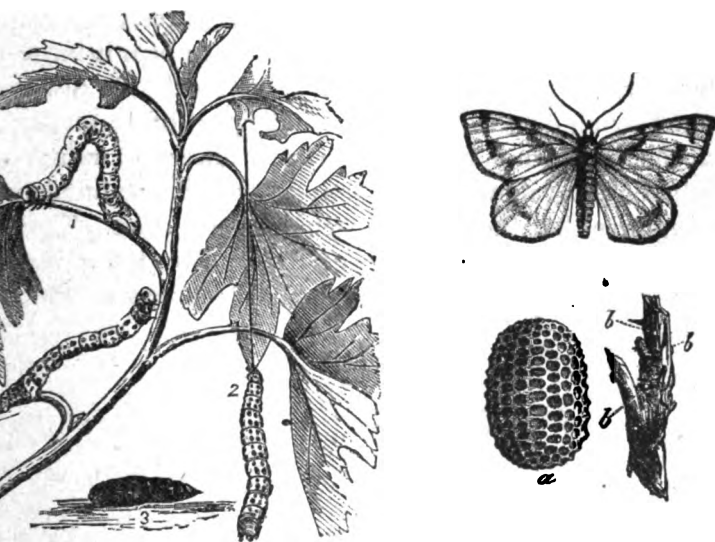


Fig. 185.—*Euftichia ribearia* Fitch. After Saunders.

after emerging from the dark brown pupa, which was formed in a small cell in the ground, the female deposits her eggs for the next year's generation. These eggs, which are most beautiful objects, are loosely glued to the stems or twigs of infested plants, and remain there until the following spring. It seems remarkable that such delicate and tender

objects should be able to withstand the rain, snow and cold of our winters without the slightest injury. All states of this insect are shown in Fig. 185.

THE CHAIN-DOTTED GEOMETER.

(*Caterva catenaria* Cram.).

The moths of this interesting geometer appear sometimes in such very great numbers as to look like a snow-storm and on that account greatly alarm the people. But usually they are not very common for a number of years, when for some reasons, perhaps absence of parasites, or assisted by suitable climatic conditions, they again appear in large numbers. Here in St. Anthony Park the moth can always be found flying about during the middle part of September; the moths are diurnal, but fly in a rather uncertain manner and only for short distances, so that a trained eye immediately recognizes that they are not genuine butterflies. The moth is easily recognized by its large size and by its snow-white thin wings, marked with numerous black spots, which are

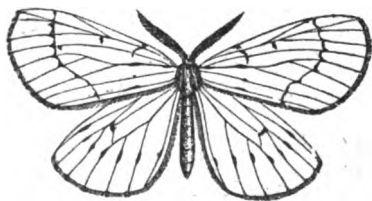


Fig. 186.—*Caterva catenaria* Cram. After Packard.

arranged in two more or less plainly marked scalloped lines; in some cases the spots are dashes, which connect with the neighboring ones, thus forming continuous lines. There is always, even in very pale specimens, a distinct discal spot. The fringe of all wings is checkered with black dots. The head is ochreous-yellow in front; the thorax yellowish at the base of the shoulder-covers. The male has a yellowish

homem and very plumose antennae. Only a single brood produced annually. The insect is shown in Fig. 186 and Fig. 187, Plate XVI.

The caterpillar, which feeds upon the hazel, blackberry, raspberry and other plants, is very handsome; it has a smooth and cylindrical body of uniform thickness, a little thicker over the first abdominal feet, and lacks any protuberances whatever; it is of a pale straw-yellow color, with two subdorsal fine brown lines, and two smaller ones on the sides, interrupted by two large and conspicuous, regular, black dots, a pair on each segment. The head and legs are dotted with black. The caterpillar grows to about one inch and a half in length. When full grown it does not descend to the ground to pupate, but forms a slight well formed web of thick yellow silken threads among the leaves. The pupa is bluish-white with a number of black spots.

The moths deposit a large number of beautiful eggs; as many as 368 were laid by a single female, which explains the fact that this insect can soon become very numerous.

THE COMMON CYMATOPHORA.

(*Cymatophora pampinaria* Guen.).

This is an exceedingly common moth, yet difficult to find, as it so thoroughly mimics the color and markings of the barks of trees upon which it rests that only well trained eyes can discover it. These moths vary greatly in color and markings but very little in size; they measure with expanded wings about one inch and a half across. The body and wings are pale ash, more or less clearly marked with three dark brown lines and numerous spots of the same color. Prof. Packard says: "that it may be known by the very distinct dark spot at the base of the abdomen, the basal ring beyond being usually white, and by the under side of the wings having

a broad marginal shade, while the third line on the fore-wing is deeply but quite regularly situate, and near the costa acutely dentate." The caterpillars are general feeders but are also found upon the apple and blackberry. They vary considerably in color; some are very pale yellow with a broad



Fig. 188.—*Cymatophora pampinaria* Guen.

reddish-brown dorsal stripe, edged with black; others are yellowish-green, while still others are gray or brown. They spin no regular cocoon, but protect their pupæ by a few silken threads. We have at least two annual generations which overlap in such a way that moths can be found all through the warmer part of the year. The adult insect is shown in Fig. 188.

THE EUROPEAN CYMATOPHORA.

(*Cymatophora crepuscularia* Tr.).

This moth (Fig. 189) is slightly larger than *pampinaria*, but otherwise resembles it. Its color is whitish-ash, finely and uniformly dusted with brown. The fore-wings have also three curved dentate black lines, which extend over the lower wings.

The caterpillar is smooth and of uniform thickness; it is pale yellow on the sides, shading to creamy-white above.



Fig. 189.—*Cymatophora crepuscularia* Tr..

A straight light-brown stripe occurs on the back, and below it are several narrow, wavy dark-brown stripes close together; all stripes become obsolete on the last segment. The roundish head is a little wider than the body and reddish-brown in color. The pupa, half an inch long, is formed in the earth.

This species is not nearly as common as the preceding one; it occurs also in Europe.

LARGE BLUE-STRIPED LOOPER.

(*Biston ypsilon* Forbes).

Early in August 1898 several nursery people complained about a large caterpillar that was causing some injury to young apple trees, many of which had been entirely defoliated. When visiting these nurseries on the following day the worms had all disappeared, and only a single specimen was found in the ground, very much contracted, as if it was ready to pupate. As this insect is evidently capable of causing much injury the description given by Prof. Forbes is here repeated, "The single male specimen bred is of a brownish gray color; head dusky gray; palpi black; antennæ dusky, widely pectinate; thorax gray, with three transverse black lines, the anterior and middle arcuate, the posterior straight. The front wings are brownish-gray, speckled with black on the basal and terminal thirds, marked with three transverse black lines with the space between the first and third pale gray, minutely speckled with black, these black marks taking the form of transverse lineations on the costa. The inner line is obliquely arcuate, its inner end being about half the distance of the outer from the base of the wing. The third line is sinuate, bending broadly forward around the end of the discal cell and then running nearly directly to the internal margin. The middle line is straight, and joins the inner end of the third before it reaches the internal margin. About one-half the distance from the third transverse line to the posterior margin is a jagged pale transverse line extending across the wing. The posterior wings are pale gray marked with two transverse lines, the inner of which is straight and the outer sinuous like that of the forewing. Beyond this is an obscure subterminal whitish band, and on the middle of the wing between these lines is a distinct black spot. The wing beyond the outer transverse line is more irrorate with dusky, the fringe pale with blackened scales

in the intervals between the veins. The first segment of the abdomen is covered with long gray pile; the remaining segments are fulvous brown, with a double row of black blotches along the middle.

"LARVA.—Length, when full grown, is two inches. The general color is a reddish drab, ornamented with numerous irregular longitudinal stripes of a reddish hue, with varied yellow and bordered with jagged lines of black. Four of these bands are continuous on the back, but vary greatly in width. On the sides they are much interrupted, the stripe below the spiracles being broken up into irregular patches. That immediately above the spiracles is regularly interrupted, disappearing at the middle of each segment. On the last two segments all the bands are much interrupted and very irregular. The dorsal stripes are confluent a little behind the middle of each segment, from the fourth to the eighth, with the exception of a central stripe of the ground color, by which all the transverse lines are broken. These confluent band-like areas of the longitudinal stripes, are, at first, yellow, but all change to a russet at the last moult, except the anterior one, which remains a bright lemon-yellow. The surface is smooth with the exception of a transverse row of about five black hairs to each segment, each arising from a minute tubercle. There is also a prominent tubercle behind each spiracle (excepting that upon the first segment) bearing a black hair at its apex. This row of later tubercles is variegated with rose and yellow, and each is surmounted by a jagged black line, which includes the black spiracle in the area described by it. The ventral surface has the same ground color as the dorsal, and is similarly marked with longitudinal stripes, which are, however, less distinct than the above. The head is irregularly punctuate, patches of the punctures being black, giving the surface a mottled appearance. The general color of the head and first segment is lighter than that of the other parts of the body. The anterior segment has a yellow front margin, interrupted in the

le by the median stripe already described. The legs are d with black and yellow at the articulations, and are here more or less spotted with black. Upon the ante-ultimate segment are the two prominent black tubercles, upon either side of the median stripe, each bearing a bristle at its apex; and similar bristles are scattered over the dorsal surface of the succeeding segments. The last segments with the corresponding prolegs are punctuate with black, and bear two smaller sets of tubercles similar to those above mentioned. The preceding pair of prolegs are irregularly striped mottled with black, rose and yellow, like the sides. e transverse rows of minute black hairs are visible the under surface, two or three to each segment." Fig. 190 is a copy of the illustration of this moth.



Fig. 190.—*Biston ypsilon* Forbes. After Forbes.

THE PEPPER AND SALT CURRANT-MOTH.

(*Eubya* (*Amphidasis*) *cognataria* Gn.).

In some years this moth is very common and as it is easily attracted to strong lights it is frequently observed. It is not alone common near St. Paul, but seems to be



Fig. 191.—*Eubya cognataria* Gn. After Packard.

common near Duluth. Like the preceding species this moth differs greatly from most Geometridæ by having

a very stout body and wings, so that it looks more like a bombycid moth. Both fore and hind-wings are gray, dotted and streaked with black, and with a wavy light band cross-



Fig. 192.—*Amphidasia betularia*. After Taschenberg.

ing the wings beyond the middle. The under surface is paler than the upper; the body is gray, dotted with black. The moth expands two inches or more. It is shown in Fig. 191.

The caterpillar is found very abundantly and often in great numbers on the currant; it feeds also on the currant and other plants. When full grown it is about two inches long; when at rest it is usually found clinging to a branch or leaf by its hind-legs, the body being extended straight out, so that it is easily mistaken for the stem of a branch. It is pale-green, with an interrupted darker green line down the back, and indistinct broken transverse lines of the same color, and a yellow cross line on the posterior end of each segment. There are two small tubercles on the segment immediately behind the head; the body is dotted with small whitish tubercles and a few short black hairs. In some cases there is a small brown tubercle on each side of the middle, and a purplish brown ridge on the last segment. As soon as full grown the caterpillar enters the ground for pupation, which is performed in a smooth cell; the pupa is dark brown. A closely related European species (*Hydriodes betularia*) is shown in Fig. 192; the illustration shows the caterpillars in two characteristic positions.

THE LIME-TREE WINTER-MOTH.

(*Hybernia tiliaria* Harris).

The caterpillars of this moth feed chiefly upon the basswood, elm, hickory and others, but are also found in some numbers on the apple. In some years the moths, at least the males, are very common, and being attracted to the light are often found in large numbers on the street-lamps. They are most numerous late in the autumn, after all the leaves have been killed by frost. It is only the male that can fly, the female being a wingless, spider-like creature, with long and thread-like antennæ, a yellowish-white body, marked on the sides with black dots and with two black lines at the top of each ring except the last, which has but one. The head is black in front, and the legs are ringed

with black. She is equipped with a jointed ovipositor, which can be lengthened or shortened at will, and which is used to deposit the eggs. The male has large and delicate wings and feathered antennæ. The fore-wings are of a rusty-buff color, with two transverse wavy brown lines, the



Fig. 193.—*Hybernia tiliaria* Harr. From Div. of Entomology, Dep. of Agriculture.

inner often indistinct, while between the bands and near the edge of the wings there is generally a brown dot. The hind-wings are paler, with a small brownish dot in the middle; the body is similar in color to the fore-wings, which measure, when expanded, about an inch and a half across. The females, as soon as they emerge from the ground, late in October or even early in November, climb up the trees, and, after mating, deposit their oval pale-yellow eggs, covered with a net-work of raised lines, in little clusters on the branches.

These span-worms, which hatch early in spring, are not like the true canker-worms, but are much larger and marked differently. The caterpillar has a dull red head, with a "V"-shaped mark on the front; the body is yellow above, with many longitudinal black lines; the under side is paler. When full grown these worms measure about an inch and a quarter in length. The different states of this moth are shown in Fig. 193.

THE WINGLESS PHIGALIA.

(*Phigalia strigataria* Minot).

This moth is also fairly common in Minnesota, the males appearing about early in April. They are pale-ash, with dark brown specks and lines, which form three blackish transverse lines across the fore-wings, with a subterminal whitish line. The hind-wings are whitish, finely dusted with dark scales, which in well marked specimens are arranged in such a way as to form a continuation of the transverse lines of the fore-wings. The antennæ are strongly pectinated. The wings have an expanse of about an inch and a half. The



Fig. 194.—*Phigalia strigataria* Minot.

female is wingless, of a light gray color with a slight olive tint; her body is mottled all over with black, the spots above being large those below fine. The thorax is nearly uniform black; the short head, scarcely seen from above, is grayish black; the clypeus and antennæ are black, the latter annulated with the ground color of the body. The divisions between the extended segments of the abdomen are

pea-green. The rudimentary hind-wings reach to the back part of the first abdominal segment; the fore-wings to the middle of the same segment. The exerted ovipositor consists of two joints, the last third of the posterior one having the hairs perpendicular to the joint. Both sexes are shown in Fig. 194.

The pupa is dark brown, coarsely punctured, the divisions between the abdominal segments finely so; the last segment is conical, smooth at the end, and tipped with two short, stout, divergent bristles.

The caterpillars are found on the apple, rose, blackberry, elm and other plants, and have thus far never become numerous enough to cause injury. They are about an inch long, dark-brown or dusky reddish-brown with dirty white or gray dorsal and dirty yellow lateral lines. They reach their full size in June, when they enter the ground for pupation and hibernation.

CANKER-WORMS.

There are two kinds of canker-worms which are known to be very destructive to the orchards, especially to the apple-trees. A third species is found in the northern portion of our state, sometimes in such immense numbers as to defoliate large tracts of forest-trees. It has thus far not been found upon fruit trees, but prefers the linden, ash and elm, but when very numerous no foliage escapes its voracious appetite, and the caterpillars pass through the forests like a devastating fire. They hatch very early in the season, and perforate the leaf-buds, thus causing much more damage than if they would simply eat the unfolded leaves. As no males have been raised thus far this third species remains undescribed; the females are wingless and deposit their numerous eggs in perfect rings around a small twig, in this respect resembling the tent-caterpillars.

THE SPRING CANKER-WORM.

(Paleacrita vernata Pack.)

This canker-worm appears in its winged form early in spring, although specimens are also sometimes found late in autumn. The females, which are wingless, ascend the trunks of trees to deposit their eggs. These are of a very delicate texture and of a pearly lustre; they are deposited in masses of several hundreds, without regularity, and are usually well hidden in the crevices of the bark. The young caterpillars are of a dark olive-green or brown color, with black shining spots, and a horny cervical-plate of the same color. When full grown they are about an inch long, of very variable colors. The head is usually mottled and spotted, and has two pale transverse lines in front; the body is longitudinally striped with many narrow pale lines; along the sides it becomes darker in color, and down the middle of the back are some



Fig. 195.—*Paleacrita vernata* Pack. After Riley.

dark spots. When mature these caterpillars descend to the ground in which they penetrate to some depth and where they make a rather fragile cocoon.

The female of this canker-worm, as well as the male, has on the posterior margin of each segment two transverse rows of stiff reddish spines. The female has a long and retractable ovipositor, which is not found in the Fall canker-worm. The male has pale ash-colored or brownish-silky fore-wings, which are so thin as to be almost transparent. A broken whitish band crosses the wing near outer margin and three interrupted brownish lines are

found between that and the base; there is also an oblique black dash near the tip of the fore-wings, and a nearly continuous black line at the base of the fringe. The hind-wings are plain pale ash-color, or very light gray, with a dusty dot about the middle. All stages of this canker-worm are given in Fig. 195.

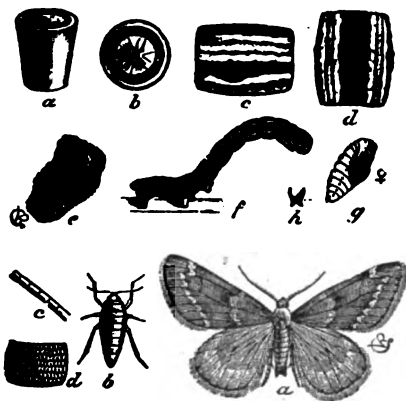
THE FALL CANKER-WORM.

(*Anisopteryx pometaria* Harr).

This delicate moth is sometimes flushed late in autumn, and frequently after all foliage has been killed by frost, when we walk along the edges of forests. The moth flies in bright sunshine, as if to enjoy the few brief hours of its existence. It is a very frail being, with wings so thin as to be almost transparent and it almost seems that it was most decidedly out of place at this late season. But notwithstanding their frail bodies all canker-worms here and in Europe are very hardy, and seem to require for their perfect health and well-being a considerable degree of cold. All the moths of this insect that we observe flying are males, the female lacking wings for this purpose. The latter is a spider-like and slug-gish being, usually having the body so distended with eggs that she has to drag it in a rather ungainly manner. All she tries to do is to reach a tree, which she climbs, and there awaits the arrival of her winged mate. Her body is uniformly colored; it is shining ash color above, gray beneath, and measures from three to four-tenths of an inch in length. The male has brownish fore-wings, which are very glossy and silky, and are crossed by two rather irregular whitish bands, the outer one enlarging near the apex, where it forms a large pale spot. The hind-wings are grayish-brown with a faint central blackish spot and a more or less distinct whitish band crossing them.

The eggs of the Fall Canker-worm are flattened above, and have a central puncture and a brown circle near the bor-

they are deposited in regular masses, side by side, and as many as a hundred together. In most cases they are laid in closed situations on the twigs or branches of the tree affected. They hatch about the time when the young leaves of the apple just expand, and this delicate food is greedily devoured by the young worms which cluster upon them. As they enjoy life, being well hidden by the still small and tender leaves. The young caterpillar is pale olive-green with a pale head and cervical-plate. Mature, it reaches a length of about an inch. The caterpillars vary greatly in color, from greenish-yellow to dusky or even dark brown; they have broad longitudinal yellowish or paler stripes along their sides. Like nearly all loopers they assume when



196.—*Anisopteryx pometaria* Harr.; a, b, single eggs; c, egg mass; c, d, jointed caterpillar; f, caterpillar; g, pupa. Below, a, male moth; b, female moth one joint of same. From Div. of Entomology, Dep. of Agriculture.

feeding a stiff posture, either flat or parallel with the twigs on which they rest, or at an angle of about forty-five degrees. In this position, kept up for many hours at a time, they so closely resemble in color and shape a small twig that they are not readily detected. When full grown they may descend the tree on foot, or they let themselves down from the branches by silken threads. When thus suspended in great numbers, as is frequently the case, they become a

great annoyance to people passing under such trees. In this manner they are also carried by passing vehicles to places not yet invaded by them. As soon as they reach the ground they burrow in it to a depth of from two to six inches and there they form a rather tough cocoon of buff colored silk interwoven with particles of earth. The pupa is about half an inch long, of a light grayish-brown color; that of the male is slender and furnished with wing-cases. The pupæ remain in the ground until late in autumn when the moths emerge.

REMEDIES.—With the exception of the one species of canker-worms so destructive to forest trees in the lake region of Minnesota these insects are not as yet of a threatening nature in our state. Both species are found, however, and it is simply a question of time when they will become more numerous. At present orchards are by no means found near every farm house, but the time is rapidly coming when this will be the case, and with more orchards the large number of injurious insects living in them will also become more numerous and destructive. These insects are rather easy to destroy with any of the arsenical preparations; in fact they were about the first tree-infesting species that were destroyed by these means. But in case of large trees it is not easy to apply them, and here we have to apply other remedies based upon the fact that the wingless females have to ascend the tree to deposit their eggs, which we can and should prevent. Prof. Saunders writes: "To attack an enemy with success, it is essential that we know his vulnerable points. In this instance since the females are without wings, if they can be prevented from crawling up the trees to deposit their eggs, a great point will be gained. Various measures have been employed to secure this end, all belonging to one or other of two classes, first, those that prevent the ascension of the moth by entangling her feet and holding her there, or by drowning her; second, those which look to a similar end by preventing her from getting a foot-

and causing her to fall repeatedly to the ground until she becomes exhausted and dies. In the first class is used tar mixed with oil to prevent its drying, and spread either directly around the body of the tree, or on a band of old canvas or stiff paper, about five or six inches wide and tied in the middle with a string; refuse sorghum molasses, printer's ink, and slow drying varnishes, are used in a similar manner. Tin, lead and rubber troughs, to contain the oil also belong to this class of remedies, and have all been used with more or less success. In the use of any of the above named sticky substances, it should be borne in mind that they should be kept sticky by frequent renewal of the material. In mild weather, or the application will be useless; it should also be applied as early as the latter part of winter, and kept on until the leaves are expanded in the following spring. It must also be remembered that some of the moths, defeated in their attempts to climb the trees, will lay their eggs near the ground or anywhere in fact, beneath the barrier, and that the tiny young worms hatched from them will pass without difficulty through a very small opening. Hence, whether troughs or bandages are used, they must be taken to fill up all the irregularities of surface of the bark of the trees, so that no openings shall be left through which they may pass. Cotton batting answers in most cases for this purpose.

The second class of remedies consists of various ingenious devices, in the way of collars of metal, wood or glass, placed around the tree and sloping downwards like an inverted funnel. These, although they prevent the moths from ascending the tree, offer but little obstacle to the progress of the young caterpillars unless the openings beneath the collar and the tree are carefully packed, and hence they often fail of entire success. Those belonging to the first class are said to be the surest and best, and while it must be admitted that it involves much time and labor to do so often and for so long a period the tar or other

sticky application so as to make it an effectual barrier to the ascent of the insect, still it will pay, wherever the canker-worm abounds, to give this matter the attention requisite to insure success. The limited power of motion possessed by the female usually confines this insect within narrow limits, and hence it is local in its attacks, sometimes abounding in one orchard and being scarcely known in a neighboring one; but when it has obtained a footing, and is neglected, it usually multiplies prodigiously. Strong winds will sometimes carry the larvæ from one tree to another near by. When the caterpillars are once on a tree, if the tree is small, they may be dislodged by jarring, when they all drop suspended in mid-air by silken threads; then by swinging a stick above them the threads may be collected and the larvæ brought to the ground and destroyed. Fall plowing has been recommended to destroy the chrysalids by turning them up, when they are likely to be either killed by exposure or devoured by birds. Hogs also are very useful in destroying this pest by rooting up the chrysalids and eating them." The use of "Raupenleim" has given very good results, and as this material remains sticky for a long time it is better than simple tar, etc.

Canker-worms have many enemies which assist us greatly to keep them in check. The eggs are devoured by a small red-mite, and a very small wasp finds the minute eggs large enough to furnish food for her offspring, hence she deposits her eggs into the larger ones of the canker-moths. The caterpillars themselves are preyed upon by larger parasitic wasps and flies, and predacious insects also feed upon them in large numbers. One of our Caterpillar-hunters (*Calosoma frigida* Fig. 145), a large black and active beetle, is found in large numbers in Minnesota wherever canker-worms have greatly increased in numbers, and they make war upon them day and night. These beetles are just as active as their green relatives farther south, and climb with equal facility. It is amusing to see them running over the

or racing up and down the trunks of the tree, trying with their front feet the worms suspended by silken threads. Evidently the caterpillars realize their danger, but if we imitate the motion of one of these beetles with a stick upon a leaf all the worms immediately drop, but are suspended in the air until they imagine all danger is over. Insect-eating birds devour large numbers, and Shrews and Munks find and devour the caterpillar above and below ground. Spiders prove also of great help, as do some wasps, such as the Potter-wasps, which store the caterpillars by them with canker-worms, as many as twenty in a single cell.

These canker-worms are general feeders but are partial to plum, cherry, linden and elm. The different states of the species are shown in Fig. 196.

THE WINGLESS OPEROPHTERA.

(*Operophtera bruceata* Hulst.).

This moth is closely allied to the canker-worms and like them possesses a wingless female; in Europe it is also almost as destructive. It is not common and the male can be readily recognized from the true canker-worms by having the ochreous fore-wing more rounded and ornamented with many wavy lines; it is illustrated in Fig. 197. The caterpillars feed upon the apple and other plants.



197.—*Operophtera bruceata* Hulst.; male.

THE SCALLOP-SHELL GEOMETER.

(*Calocalpe undulata* Linn.).

This is a rather common moth, but always attractive on account of its beautiful marking. It has white or yellowish

wings, the upper ones crossed by at least twelve fine zigzag dark-brown lines, so that it is difficult to say what is really the ground color; the hind-wings are crossed by six light lines, which become whitish toward the outer edge of the wing, as well as more scalloped. Below the wings are clearer, with the lines more obsolete, but the discal spots large and distinct. With expanded wings this moth measures about one inch and a half. It is shown in Fig. 198.

The caterpillars hatch from eggs which were deposited in a cluster on a leaf near the tip of a twig, usually on the wild cherry. They form an exception to most other loopers



Fig. 198.—*Calocalpe undulata*
Linn.

by being gregarious. They spin a snug nest by fastening together the leaves at the end of the twig, inside which they live, adding to the nest if more space and food is required. As the enclosed leaves die and become brown, and as the dark excrement also

accumulates, such nests become conspicuous and can easily be seen and removed with their contents. The caterpillars, which are quite sluggish in all their motions, are black above with four white stripes, and flesh-colored below. They transform in the earth, in which they also pass the winter.

THE GRAPE-VINE PETROPHORA.

(*Petrophora diversilineata* Hub.).

This pretty yellow moth, also called the "Diverse-lined Geometer," is very abundant in Minnesota, flying from late in June to early in September; it is often attracted to light and enters our houses at night, settling on the walls with its abdomen curved over the back (Fig. 199, Plate XIV.) It varies in size, measuring with expanded wings from an

and a quarter to fully two inches. It is shown in two in Fig. 199.

The body and wings of this insect are ochreous-yellow, pale in the middle and basal portions. The fore-wings crossed by three rusty-brown curved lines, the outerly dentate in the middle; beyond this is a subterminal line, not always distinct. The hind-wings are paler than the fore-wings, clear, usually without lines except in the outer third near the anal angle, where there is a faint line edged on the outside with white. At the anal angle is a dark spot composed of two brown lines, with a brown between them. The moths vary greatly in variety of colors and markings, some being almost plain reddish-brown with but very few indistinct bands, of which the outer dentated one is always visible.

The moths deposit their eggs upon the leaves of the vine, from which the young caterpillars hatch a few days later, reaching their full size in about four weeks. They are then about an inch and a quarter long, have a dull



Fig. 199.—*Petrophora diversa* Hub.

reddish-brown head, a yellowish-green body, with a few small whitish dots on each segment. On each side of the second segment is a small reddish spot and on the third a larger one of a darker shade; on this latter segment there is a fold in the skin, which makes the spot appear as a brown prominence. On the terminal segment are two short greenish spines, which point backwards; the surface of the body is wrinkled; the under surface is reddish, with a central reddish line bordered with white, which is margined with dull red. The caterpillars are also very variable in color, but are very well protected by blending with the surroundings; when disturbed they straighten themselves, remaining per-

fectly quiet for a time, and resemble the twigs so thoroughly that is very difficult to detect them. When they are full grown they hide in some shelter, and thus pass the winter; early in spring they leave their hiding places and after eating for a few days they transform to pupæ and soon afterwards to moths.

At present these caterpillars are found most abundantly in places where wild grapes are growing, but they are by no means strangers to our vine-yards, where they eat a large amount of foliage, thus sometimes causing some slight injury. Being so well protected by shape, color and position they may be very common on our vines, yet are not recognized.

THE CURRANT FRUIT WORM.

(*Eupithecia interrupto-fasciata* Pack.).

This is not a common moth, at least it is not often found in our gardens. But the fruit of wild currants frequently show its presence, or rather that of the worms. These are about five-eighths of an inch long, and very variable in coloration and markings. Their bodies are usually of a pale-ash or yellowish-green color, with a dark line down the back and another one on each side, which is, however, frequently absent. In some cases there is a row of dark-colored lozenge-shaped spots along the dorsal line, and a second lateral line lower down. The terminal segment carries two short greenish lines; the under side of the body is pale-greenish and almost white, with a yellowish line in the middle. The head varies from yellowish or greenish to light brown. When full grown the caterpillar draws together a number of leaves and other material, fastens them with silken threads, and in this shelter changes to a pupa and later to a moth.



Fig. 200.—*Eupithecia interrupto-fasciata* Pack.

The small moth has bluish-gray fore-wings, with a dot near the center of each, and a dark line crossing immediately beyond the dot. Two forms are illustrated in Fig. 200.

All the following moths are usually called "micro" or "micro", although as a matter of fact some of them are as large as, or even larger than a few of the "macros" described above. But generally speaking all are small. They are also divided into many superfamilies and families.

PYRALIDIDÆ.

This super-family includes moths of medium and small size, which differ so greatly in appearance, however, that it is not possible to give a general description that would adequately characterize the same. It includes a number of species that contain numerous insects injurious to plants.

FAMILY PYRAUSTIDÆ.

These moths have slender bodies rather thinly covered with scales. The caterpillars are nearly always green, with stripes and spots, and without any markings whatever. Their head is either black or yellow, hard and polished; so is the rather prominent cervical-shield on the first thoracic segment. Most of them have the abdominal or lateral legs crowded with a complete circlet of spines, and by this character, which is easily seen, we can tell with almost absolute certainty the caterpillar of a *micro* from that of a *macro*, in which the circlet of hooks is never complete. The caterpillars of the *Pyraustidæ* differ from those of the *Loopers* in possessing all four pairs of prolegs. Most of them produce a little silk, and they live often more or less concealed in leaves folded and tied together in various ways. A few are gregarious and build large nests. Most of the caterpillars cause no injury to cultivated plants, while a few of them are decidedly destructive.

THE GRAPE-VINE LEAF-FOLDER.

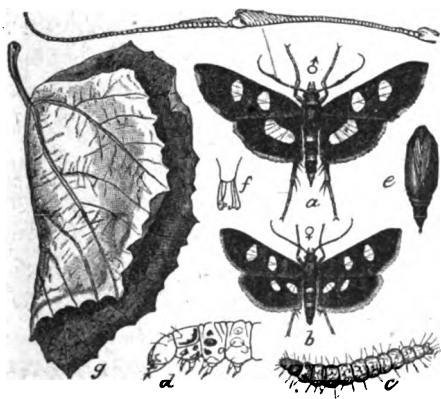
(*Desmia maculalis* Westw.).

It is a good thing that this insect prefers the South, and is not often met with in Minnesota, although it is found here both upon the wild and cultivated grape-vines. It can become a very destructive insect and one that is not readily combatted.

We see frequently the leaves of the grape folded or rolled up by means of numerous little cords of silk; if we unfold these we find the enclosed leaves skeletonized by a very active worm, a little less than an inch long and remarkable on account of its violent wriggling motions. In most cases the caterpillar wriggles out of the folds and drops either to the ground or suspends itself by a silken thread. If the worm is full grown it is yellowish-green, a little darker above, glossy and semi-transparent, with a few fine yellow hairs on each segment. Its head is reddish-yellow; the cervical-shield has a crescent-shaped patch of the same color; on the third segment are two or three black spots on each side, and on the twelfth segment is one. The caterpillars transform to a reddish-brown pupa, about half an inch long, either within the folded leaf or more usually within a much smaller fold of the edge of the leaf. In the Southern States there are two and even three annual broods, the last one hibernating in the leaves. The first moths appear here early in June, and deposit their eggs singly on the leaves of the vine; the moths of the second brood are found early in August.

The moths, which expand about an inch, are pretty insects with shining opalescent black wings, lightly fringed with white; the fore-wings have two white spots, nearly oval in form; the hind-wings but one large white spot in the male, which in the female is divided into two. The body is black, crossed by two white bands in the female, by one in

ale. The male insect has the antennæ elbowed and bent near the middle, a character not seen in the female, the antennæ are uniform and thread-like. Though common the moths are not often seen, as they hide among the leaves, but if the vines are shaken they seek and escape in quick flight, and make for the next shelter. The insect feeds upon all kinds of grapes, but shows some little preference for the thicker leaved varieties. The upper surface of the leaves is eaten by the worms, and for this purpose the leaves are almost invariably folded in such a manner as to bring the upper sides of the leaves together. Fig. 201 shows the different stages of this insect.



—*Desmia maculalis* Westw ; a, male moth; b, female; c, larva; d, head and thoracic segments of same enlarged; e, pupa; f, tip of same enlarged; g, leaf folded by insect. From Div. of Entomology, Dep. of Agriculture.

REMEDIES.—As it is easy to detect the folded leaves the billars enclosed in them can be crushed, and if this is done carefully and at a time when the insects are not yet hatched this remedy is a good one. The treatment with chemical poisons is not as successful, as the inside of the leaf can not readily be reached.

THE CRANBERRY FRUIT-WORM.

(*Mineola vaccinii* Ril.).

This insect is a very injurious one in places where cranberries are grown on a large scale for any length of time. Its caterpillar stands in the same relation to the cranberry as the apple-worm to the apple, and the grape-fruit worm to the berry. The moth is dull gray; the fore-wings are reddish-brown and tawny on their inner portions, and with the pale costal parts nearly pure white, which strongly contrasts with the dark shades, and fully relieves the basal branch of the forked shade on the inner part of the basal line, which is usually darker than the posterior branch. The hind-wings are pale gray, without any markings. The eggs, which when laid are soft and adapt themselves more or less closely to the object to which they are attached, are laid singly, and generally on the lower end of the forming fruit, or in the scar left by the flowers, or under the four flaps that cover the scar, being thus well sheltered and difficult to detect; sometimes they are deposited upon the surface of the young fruit. Their color is white, with a faint yellowish tinge. As soon as the caterpillars hatch they eat their way into the heart of the berry, and not satisfied with one they go to the neighboring ones, thus ruining from three to four berries before they reach their full growth, which takes place when the fruit is ripe. The caterpillar now stops the last entrance hole with a silken web; the affected berry turns prematurely red and finally shrivels and drops. The worm is at first pale, but becomes green, with more or less pink, and reaches a length of about half an inch. Such caterpillars are found of all sizes during autumn, a few even persisting until winter; most of them leave, however, the ripening berries in September or October, and find shelter in the higher ground, where they hibernate in an ovoid cocoon of silk, covered with grains of earth and sand. The brownish-yellow pupa,

ch brown stigmata and a shallowly punctate abdomen, formed the following spring, and the moths issue quite regularly during the month of June, or by the time the cranberries are forming.

As the growing of cranberries is becoming quite an important branch of horticulture it will not be out of place to mention the remedies suggested by the Division of Entomology: "The arsenical mixtures carefully sprayed during June and July so as to reach the calyx cavity, will prove the most satisfactory preventive of this insect's injuries by kill-

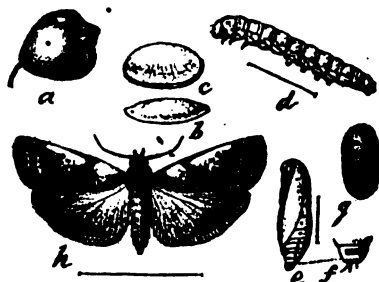


Fig. 202.—*Mineola vaccinii* Rll. From Div. of Entomology, Dep. of Agriculture.

the young larva as it attempts to eat its way into the berry, while experience would indicate that the natural growth of the berry, together with the effect of summer rains, will rid the fruit as it matures of whatever trace of the poison might prove injurious." Keeping the cranberry as wet as possible during July also seems to be a good remedy. The life-history of the insect is shown in Fig. 202.

THE LEAF-CRUMPLER.

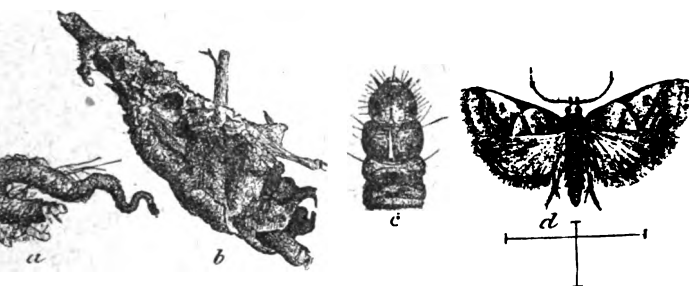
(*Mineola (Phycis) indigenella* Zell.).

This injurious insect is becoming very numerous in Minnesota, and steps should be taken to destroy it now. It seems to be equally fond of the foliage of the apple, plum and cherry. When we examine the trees late in autumn or

during winter we find fastened to the twigs some crumpled and withered leaves. If these are investigated a little closer we can detect, well hidden among these leaves, clusters of peculiar little cases, which resemble minute horns, open at one end, tapering to almost a point at the other, and twisted in all sorts of manner. The withered leaves are very firmly fastened to these little horns and to the twigs by strong silken threads; the horn itself, tightly attached to the bark, is constructed of silk interwoven with the dried excrement and frass of the worm. Its inner surface is smooth and whitish, its exterior rough and brownish. When we open one of these little cases we find in it a small caterpillar, which was born late in summer, and had reached about one-third of its full size before making and entering the case for hibernation. Early in spring, when the buds of the trees commence to expand, these caterpillars also become active again, and with an appetite sharpened by the long fast they leave their cases or homes, usually during the night, and draw the still young and minute leaves towards their dwelling-places, fastening them by means of some threads of silk; they can now enjoy a meal upon their very doorsteps, having at the same time a safe retreat in case of danger. Here the caterpillar thrives until it has reached its full size, when it measures about six-tenths of an inch in length. Its body, which is slightly tapering towards the posterior end, is of a dark, dull, greenish-brown color; the head is dark reddish-brown; the first segment has a horny plate at the top and a flattened blackish prominence on each side, below the plate; on each side of the other segments are several small blackish dots, from every one of which arises a single brown hair. By the early part of June the caterpillar is mature; it now shuts itself up in its case and changes to a reddish-brown pupa, about four-tenths of an inch long, from which the moth escapes about two weeks later.

This moth has pale brown fore-wings, with patches and streaks of silvery-white; the hind-wings are plain brownish-

the under side of both wings is paler. With spread wings the moth measures about seven-tenths of an inch across. There is but one annual generation. Notwithstanding the protection of this snug case the caterpillar is by no means secure from enemies and several parasites are known which keep this insect in check. The insect is illustrated in Fig. 203.



203.—*Mincola indigenella* Zell.: a, a single case; b, case covered with leaves; c, front part of caterpillar; d, moth. After Riley.

The best remedy we possess against it is to pick off the cases with the crumpled leaves during the time when the tree is bare of foliage, and to burn them. In extreme cases the early application of any of the arsenical insecticides will be successful.

THE WALNUT CASE-BEARER.

(*Mineola juglandis* LeB.).

There are a number of other case-inhabiting caterpillars, but the one living on the walnut and hickory is found quite common but by no means as common as the one just described. The caterpillar of this insect makes a straight case, which is much more neatly woven together on the outside. It is attached with its smaller posterior end to the main leaf-stem, and the caterpillar draws down and fastens two of the leaflets to hide it and then feeds upon it from the point

to the base. The caterpillar has the same general appearance and is of the same size as that of the apple-leaf crumpler but is darker greenish. It has many enemies and there is

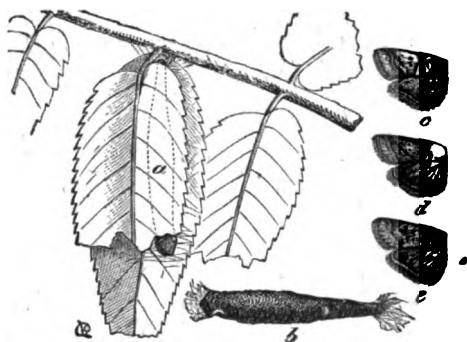


Fig. 204.—*Mincola juglandis* LeB.; a, case indicated; b, case; c, d, e, wings.
After Riley.

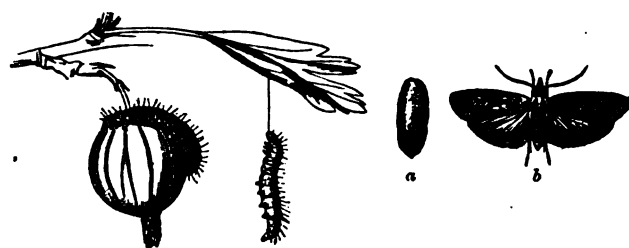
hardly a necessity at present to fear its occurrence. If it should become more numerous, especially in our windbreaks or where walnut trees are planted in large numbers, it can be kept in check like the closely allied insect described before. It is shown in figure 204.

THE GOOSEBERRY FRUIT WORM.

(*Zophodia grossulariæ* Pack.).

Many of our farmer's wives depend on wild gooseberries for preserves, and as our state abounds in such fruit there is usually no lack of material for this purpose. But notwithstanding the abundance of these berries there are seasons when the crop is destroyed entirely, or at least reduced very materially, by the presence of the above insect, the larvæ of which burrow into the berries. As they grow larger they fasten a number of berries together with silken threads; they even cut off the stems of some so that they can be brought into the desired position. These united berries form a shelter and a storehouse of food. Only a

The hole is made in each berry just large enough to admit the body of the worm. Like all caterpillars of such insects the worms are very active, and if their house is ever so disturbed they leave it very suddenly and drop to the ground by a silken thread, which enables them later to return to their dwelling places. When full grown this caterpillar, which is shown in Fig. 204½ suspended by a thread also upon a berry, is about three-quarters of an inch long; its body is thickest in the middle, tapering slightly toward each extremity, of a pale green color, sometimes with a yellowish or reddish tint, glossy and semi-transparent. It has a small, horny and pale brown head, the dorsal shield has also the same color. Before the berry the larva drops to the ground where it makes a snug, paper-like cocoon among the dead leaves and rubbish; inside this safe shelter it transforms to a brown pupa, which remains inactive until the following spring. There is but one annual generation.



204½.—*Zophodia grossulariæ* Pack.; a, cocoon; b, moth. After Saunders.

The moth appears soon after the gooseberry is past its prime, when it deposits the eggs upon the fruit just before it is gathered. The wings of the moth expand nearly an inch when fully expanded; "the fore-wings are pale gray, with dark streaks and spots, there is a transverse diffuse band a short distance from the base of the wing, enclosing an irregular whitish spot which terminates before it reaches the front edge of the wing. Near the outer edge is another transverse band en-

closing a whitish zigzag line, there is also a row of blackish dots within the outer margin, while the veins and their branches are white, the hind-wings are paler and dusky. The head, antennæ, body and legs are all pale gray, whiter below than above." (Saunders).

The insect is not easily combatted, but as it can readily be detected it can also be destroyed to some extent by hand picking. If neglected it increases very rapidly and no berries can be expected until parasites or unsuitable climatic conditions come to our assistance. Chickens running among the bushes after the fruit has been gathered will find and eat many of the pupæ. The removal and burning of all rubbish is also of some value, and in extreme cases the proper use of arsenical poisons is recommended.

THE AMERICAN PLUM-BORER.

(*Euzophera semi-funeralis* Walk.).

Professor Forbes has described this insect in detail, and as a few specimens have been received from a nursery there is no doubt that it occurs in the state. The caterpillars attack the plum-tree near the forks, especially at the base of the lower limbs; in such places they crowd together and destroy the bark in large irregular patches.

Prof. Forbes writes: "Living borers received 3 November were about half an inch in length, of a greenish dusky color, with only a few scattered hairs springing from small dark specks. The head was reddish-brown, with a darker triangular patch in the middle, and the top of the first segment behind the head, the cervical shield so called, varied from yellowish to pitchy, more or less shaded with brown, but with a median yellow patch. This borer has, of course, the three pairs of legs and the fleshy prolegs (ten in number) of the caterpillar. From the peach-borer, whose structure is similar, it may be distinguished by its dusky

(the other being white), its smaller size when full grown, and with a glass by the hooks on the prolegs. In the plum-borer the ends of the soft stump-like legs are provided with small brown hooks, arranged in two opposite curves discontinuous at their ends, each of a single row; while in the new plum-borer the corresponding hooks form a complete ring, nearly covering the end of the leg.



FIG. 205.—*Euzophera semi-funeralis* Walk. After Forbes.

“Kept in a breeding cage and supplied with the chips and twigs of the plum trees, our larvæ spun small webs in which they passed the winter. By 3 May a part had pupated, and 28 and 29 May two winged moths emerged, all the others failing.

These moths were small gray insects, the extended wings measuring about eight-tenths of an inch. The fore-wings reddish behind (within); the hind-wings were plain.” Illustrated in Fig. 205.

THE APPLE-LEAF SKELETONIZER.

(*Canarsia Hammondi* Ril.).

In some regions of the United States this insect is very common and correspondingly injurious. As it is also found in Minnesota its life-history is given, so that in case it should become destructive it may be recognized and treated accordingly.

The leaves of apple-trees, and especially of the younger ones in the nurseries, appear sometimes blighted, corroded and rusty. If we search for the cause for this injury we find it to be produced by the gnawings of little worms, the young of this insect, which feed solely on the green pulp

parts of the upper surfaces of the leaf, not touching the harder and more fibrous frame-work of the same. In extreme cases this green substance has been so thoroughly removed by the jaws of the worms that nothing remains but the semi-transparent epidermis below and the net-work of veins; in most cases, however, a little of the parenchyma is left, which assumes a bright russet-red color. The caterpillar always covers the leaf with loose silken threads, with which are mixed the minute grains of the gunpowder-like

excrement; below this covering it is protected and here it feeds singly or in groups; in the latter case a number of leaves are drawn together to give additional shelter. The caterpillar is pale-brownish, about half an inch long, and marked with four conspicuous black shining tubercles, with a pale basal annulation near the head. The pupa is generally formed among the leaves in a very slight cocoon; it is of a pale brown color and

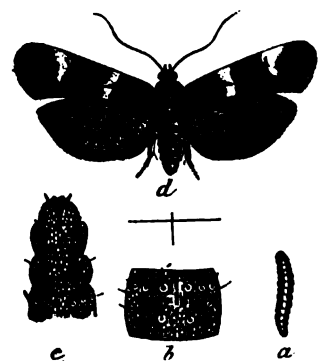


Fig. 206.—*Canarsia Hammondi* Ril; a, larva; c, front part of same, enlarged; b, on joint still more enlarged; d, moth. After Riley.

about a quarter of an inch long. In confinement the caterpillars go below the surface of the ground, and in this case they cover their cocoons with grains of sand. The insect hibernates in the pupal state. The insect is shown in Fig. 206.

The strangely marked moth has the fore-wings of a deep, glossy, purplish-gray, marked with two silver-gray transverse bands.

This insect is also preyed upon by a number of parasites, which in Minnesota seem to be able to keep it well in check. A little of the arsenical poisons used in time will prevent injuries, especially in our nurseries, where the insect can become a decided nuisance.

FAMILY PTEROPHORIDÆ OR FEATHER-WING MOTHS.

is a very interesting little family of small slim insects which are distinguished by having long slender legs and narrow fore-wings split into lobes, feathers or plumes. Occasionally the fore-wings have only one cleft or notch which does not extend beyond the middle, but sometimes they are split their full length. The hind-wings may be divided into from four to six lobes or feathers. As a general rule these insects are not very common or infest wild plants; however, they can become quite injurious to cultivated plants. It is strange how rapidly insects of all kinds will increase in numbers if food is abundant and enemies scarce. An interesting case near the Experiment Station a few years ago. A good many new streets were opened and the soil taken from them, in most cases clear sand, was laid upon some low lots with the view of raising them to the level of the street. Upon this sand nothing would grow for two seasons but the common thistle, which flourished however, to such an extent as to form an impenetrable mass. About the time that the first flowers were to expand all the terminal branches of the plants died and it was found that each branch was inhabited by a single larva of a feather-winged moth. The thistles, however, were covered, and each plant sent out a number of new ones, which produced a large number of flower buds; these were also destroyed by a second generation of these moths which in turn were killed by parasites, so that after a while the plants succeeded in producing numerous seeds but much later than usual.

THE RASPBERRY PLUME.

(*Oxyptilus tenuidactylus* Fitch).

is a very beautiful little moth and by no means very common. It measures about an inch across the expanded wings. The head and thorax are dark tawny-brown with a

tinge of coppery-red; the posterior part of the thorax is white. The fore-wings which have a deep brownish or coppery color with a metallic lustre and a few short silvery-white lines, are cleft down the middle about half their depth; this division, as well as the outer edge, is fringed. The hind-wings, which resemble the fore-wings in color, are cleft into three parts, of which the posterior one is almost linear; all are deeply fringed. The antennæ are ringed with silvery-white, and spots of the same color are also found upon legs and body, the latter having the same color as the wings. When at rest the wings are closed in a very peculiar fashion.

The caterpillars of this moth are found full grown towards the middle of June; they are then about four-tenths of an inch long, of a pale yellowish-green color, streaked



Fig. 207.—*Oxyptilus tenuidactylus* Fitch. After Saunders.

with pale yellow, and with transverse rows of shining tubercles, from each of which rise from two to six spreading hairs of a yellowish-green color. The small head is pale green, with a faint brown dot on each side. The caterpillar spins a loose web between leaves, and in it changes to a pupa, which is suspended somewhat like the chrysalis of diurnal butterflies, which it also resembles, not being rounded as are most of the pupæ of moths but being quite angular. It is less than three-tenths of an inch long, pointed behind, enlarging gradually towards the front, where near the end it slopes abruptly to the tip. It is of a pale green color, with a darker green line along the back, margined on each side with a whitish ridge; the pupa is more or less hairy. Before the perfect insect escapes the pupa gradually assumes a darker color. The insect is shown in Fig. 207.

At present this insect, which feeds also upon the black-berry, is not common enough to cause injury.

THE GARTERED GRAPE PLUME.

(Oyptilus periscelidactylus Fitch).

This moth is sometimes quite abundant, and has else-
 caused some injury to the foliage of the grape-vine.
 Caterpillars appear very early in spring, or as soon as
 leaves unfold; they have the bad habit of fastening to-
 the terminal leaves into a large ball, within which
 live, feeding upon the tender leaves and young bunches
 of flowers. This habit causes the caterpillars to do con-
 siderable damage, but when we investigate the case more
 thoroughly we find that after all this is not so great since in
 many cases they do not commence operations until the
 buds of flowers are already too large to be enclosed in the
 leaves, hence are not always eaten. The insects reach their

full size quite early, giving the
 damaged shoot an opportunity to
 send out a new spur from the last
 leaf, so that the effects from the
 presence of the worm are scarcely
 noticed afterwards. In June the
 worms reach their full size, when
 they are about half an inch in
 length, of a yellowish-green color,
 with transverse rows of dull yellow
 tubercles, from each of which arises
 a small tuft of white hairs. Owing
 to these tufts of hairs the cater-
 pillars resemble those of some
 "Woolly Bears." A line along the
 back is of deeper green, and the
 body is paler between the seg-
 ments. The small yellowish-green
 head has a black band across the

; the feet are black, tipped with pale-green; the
 and thin prolegs are greenish. As soon as mature



208.—*Oyptilus perisceli-*
actylus Fitch. a, caterpillars;
 b, c, peculiar horn on back
 of caterpillar; d, moth; e, one segment
 of caterpillar. After Riley.

the worm spins a few silken threads on the under side of a leaf, or in some other sheltered spot, and having entangled its hind-legs firmly in this web of silk it sheds its hairy skin and becomes a pupa, which is a very odd looking affair, about four-tenths of an inch long, very angular and rugged, and most decidedly active if touched. It possesses on the middle of the back two rather long and compressed horns placed side by side, and extending upwards; other projecting points and ridges are also found. Its color is pale yellowish-green. After remaining in this condition for about two weeks it gives forth the perfect insect. Fig. 208 shows this insect in its different states.

The moth, expanding about seven-tenths of an inch, is a very pretty insect; it has long and narrow fore-wings, cleft down the middle about half way to their base, the posterior half of the wing possessing a notch in the outer margin. Their color is yellowish-brown, with a metallic lustre and several dull whitish streaks and spots. The hind-wing is colored in a similar manner, and is divided into three lobes; the lower division is complete, extending to the base; the upper one not more than two-thirds of the distance. All margins of the wings, including those of the lobes, are bordered with a broad whitish fringe, sprinkled here and there with brown; the long and slender body is a little darker than the wings; the moderately long and thread-like antennæ are nearly black, beautifully dotted with white throughout their whole length. The legs are long, alternately banded with yellowish-brown and white, the posterior ones ornamented with two pairs of diverging spines, which possess at their base a garter-like tuft of long brown scales.

The moth produces but one annual generation, hence is not very difficult to keep in check by picking off the infested tips, or by crushing the caterpillars within the webbed leaves.

SUPER-FAMILY TORTRICINA OR BELL-MOTHS.

These moths are generally small, with broad fore-wings usually squarely cut off. The front margin of the wing curves inward very strongly near the base of the wing, and at rest broad fore-wings fold above the body like a roof. The colors are usually of the color of the body and frequently without markings. Most of the caterpillars, which, however, vary greatly in habits, are leaf-rollers, and this habit suggested the name "Tortrix." The leaves are rolled together in various ways, and are not simply used as shelter but also as food, and in many cases such a leaf is at first a nest for an entire brood of caterpillars.

THE FAMILY TORTRICIDÆ OR TYPICAL LEAF-FOLDERS.

Considerably more than one hundred different kinds of moths belong to this family. Most of their caterpillars are decidedly injurious and not a few are found upon our producing plants.

THE CRANBERRY LEAF-FOLDER.

(*Teras oxycoccana* Pack.).

Only a single specimen of this insect was found near Rapids, showing, however, that the moth exists in our State, perhaps in large numbers. If the growing of cranberries in our numerous bogs, some of which are well adapted to this purpose, should become much more of a business than it is now there is but little doubt that this insect will prove destructive. It is a small moth, spreading only three-fourths of an inch across the wings, with brown reddish-brown fore-wings with a peculiar silky sheen; the red tint is caused by scattered bright-red scales. Hind-wings are glistening gray; the body is of a dark

slate color, with a pale tuft of hairs at the tip of the abdomen.

Prof. John B. Smith who has studied very closely the insects infesting the cranberries, has come to the conclusion that by keeping the bogs covered with water until after the middle of May, thus compelling the moths to deposit their eggs on other plants belonging to the same natural family, the intelligent cranberry-grower can prevent or greatly lessen the damage done by this and allied insects.

THE LESSER APPLE LEAF-FOLDER.

(*Teras minuta* Rob.).

This insect occurs sometimes in great numbers and is consequently injurious to apple-trees, especially the younger ones, or those still in the nursery, and causes them to look as if scorched by fire. The caterpillars are small greenish

larvæ, smooth, with pale brown heads and whitish markings. They appear early in spring, and by drawing together the still tender leaves with silken threads they form a sort of protecting roof over themselves, which serves both as a shelter and as food. The second brood does not form this protecting shelter, but simply constructs a web over the surface of the leaf. The full

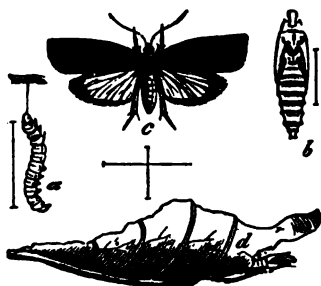


Fig. 210. — *Teras minuta* Rob.; a, caterpillar; b, pupa; c, moth; d, empty pupal skin projecting from folded leaf. After Riley.

grown caterpillar eats off the upper cuticle of a portion of a leaf, and then brings the edges together, tying them with silken threads, so as to form a snug little retreat lined with white silk, inside of which it changes to a brown pupa, about three-tenths of an inch long. Some segments of the pupa are furnished with minute spines and the posterior

mity has two hooks bent downwards; by means of these hooks it works itself half way out of the fold before the escape of the moth. See Fig. 210, *d*.

The moth has the head, thorax and fore-wings of a bright orange color; the hind-wings, body and legs are ash, with a silken lustre. The moth expands about half an inch across the wings.

The first brood appears very early in spring, in time to deposit their eggs on the young and just unfolding foliage; the second brood is common during the latter part of July.

PACKARD'S YELLOW CRANBERRY WORM.

(*Teras vaccinivorana* Pack.).

This is considered a variety of the above insect. It is a common insect in the eastern cranberry bogs and may occur in Minnesota. The caterpillar of this insect eats the leaves of the cranberry together with silken threads, and feeds upon their upper surface; it is pale yellow with a slight greenish tinge, with a few fine, long, pale hairs arising from prominent tubercles.

THE GREEN APPLE-LEAF TYER.

(*Teras minuta* var. *cinderella* Ril.).

This is considered as being simply a slate-colored variety, but sufficiently well-marked to deserve a name. Its wings are of a glossy dark ash-gray color; the hind-wings are a little paler.

The small caterpillar, which is yellowish-green, with a yellow head and neck of a deeper yellowish color, has a heart-shaped black mark upon the former. Like all leaf-tyers or leaf folders it draws together the edges of a leaf and forms a fold within which it resides. It is a very active and minute worm,

which wriggles quickly out of its case and drops to the ground as soon as disturbed.

All these insects are rather difficult to exterminate on account of their method of living in protecting folds, but repeated spraying at the proper time with arsenical poisons will prove successful.

THE OBLIQUE-BANDED LEAF-ROLLER.

(*Cacæcia rosaceana* Harr.).

This is a very common insect found upon the apple, plum, cherry, rose, raspberry, gooseberry, currant, strawberry and other plants. In some seasons it is decidedly injurious, and many complaints are made, especially by lovers of the rose, whose pets are disfigured by the presence of such worms. When mature they are about three-quarters of an inch long, of a pale-green or yellowish-green color, but sometimes reddish or brownish, with head and cervical-shield brown; there is usually a darker green stripe along the back, and a few smooth dots on each segment, from each of which arises a short fine hair. The young caterpillars appear as soon as the buds of the apple-tree begin to unfold; they roll up and fasten together the still tender leaves which furnish them both shelter and food. When mature the caterpillar prepares its old dwelling place into a safer retreat by lining its inside with silk; it now changes to a pupa of a dark-brown color, from which issues towards the end of June or early in July the winged insect, shown in Fig. 211, Plate VIII.

This and a few other closely allied moths are characterized by a peculiar form; when their wings are folded they are short, broad and flat insects, resembling bells in outline; the expanded wings are very much arched on the front edge, curving in a contrary direction near the tip. The body of the moth is reddish-brown, the fore-wings of a light cin-

mon-brown crossed with wavy darker brown lines, and with three broad, oblique, dark-brown bands, one of which covers the base of the wings and is sometimes indistinct or wanting; the second crosses the middle of the wings, and the third, which is broad on the front edge and narrow behind, is near the outer hind margin. The hind-wings are pure-yellow, with the folded part next to the body blackish. The moth expands nearly an inch across the wings; it varies considerably in color, but the description given will fit the majority.

Besides eating the foliage the caterpillars are also very fond of the skin of the young apple, and the spots abraded by them soon change to a brown and rusty color, or crack open. The injury caused by these worms is sometimes greater than is warranted by their size, especially if they have selected the terminal branches of a tree for their home; in this case the growth of the branch is checked for quite a long time.

Notwithstanding the fact that the leaf-rollers form hollow cylinders firmly fastened together with silken threads, and other equally snug quarters as a protection against birds and other enemies, they are readily found by a number of parasites. The Baltimore Oriole, with its pointed beak, rarely makes a mistake in finding the worm, and in most cases the first attempt to pick up the hidden insect is successful, as shown by the single perforation found in such paper cylinders.

Hand-picking done early in the season is always a good and safe remedy, but can only be done in small orchards with low-growing trees. If the insect becomes at all numerous we should spray the trees with arsenical poisons.

THE ROSE LEAF-FOLDER.

(*Cacœcia rosana* Linn.).

This common leaf-roller, found both in Europe and the United States, feeds also on the apple, wild-rose, raspberry, hazel, hawthorn, currant, gooseberry and other plants. It has not yet been found in Minnesota, but may occur here.

THE CHERRY-TREE LEAF-FOLDER.

(*Cacœcia cerasivorana* Fitch).

Caterpillars of this insect are frequently exceedingly numerous, not alone on the wild cherries but on the cultivated ones as well. As long as they are still young they are not readily detected, but as they grow older they draw together with silken threads the leaves and twigs of the infested plant, and in this manner form a very large and unsightly nest. The caterpillars, which are gregarious in their habits, feed inside these enclosures; they are about five-eighths of an inch long, nearly cylindrical, and have a black head; the body is yellow above and a little paler between the segments, and is covered with a few very fine yellowish hairs. The anterior portion of the second segment and the posterior portion of the terminal one is black; there is also a faint dorsal line of a darker shade; the under side is similar to the upper in color and the six true claw-like feet are black. The caterpillars change to pupæ inside the nest, and these latter, when about to give forth the moths, work their way out and hang suspended from the outer portion of the nest, clinging to it only by the hooks at the tail end of their bodies. Here the winged insects emerge, leaving the empty pupal skins projecting from the web. The pupa is of a pale brown color. The moths vary greatly in size, ranging from our-fifths of an inch to one and one-fifth inches across the

anded wings. These latter are broad and flat, the outer edge of the fore-wings being rounded towards the base, and straight from the middle to the tip; they are crossed by angular wavy bands, alternately of bright ochre-yellow and pale leaden blue; the yellow bands are varied with darker spots, the most conspicuous of which is placed on the outer margin of the tip, and from this spot a broader ochre-yellow band extends towards the hind angle, and curves thence to the inner angle; the hind-wings and



Fig. 212. — *Caccœcia silvorana* Fitch.

under surface are pale ochre-yellow. This moth is shown in Fig. 212, and also on Plate VIII.

There are seasons in which these caterpillars are so numerous that whole trees, especially the smaller varieties of wild cherries, are entirely enclosed by several united webs, so that all leaves are eaten, so that frequently nothing is left but a few cherries, which, however, shrivel before long. If the unsightly webs should be removed with their hands and should be burned. Any application with chemical poisons would be useless at this time, as the leaves could not well be reached on account of the web enclosing them.

THE CRANBERRY LEAF-ROLLER.

(*Caccœcia paralella* Rob.).

A few of these insects were observed during the middle of June in a swamp near St. Anthony Park, and a closer inspection showed that a number of cranberry plants were webbed together. The caterpillars were about three-fourths of an inch long, reddish, with yellow heads, and a number of prominent warts upon their backs; from each one of these tubercles grew one or more rather long and stiff hairs. Some of these caterpillars pupated in confinement, but as

they agreed very well with the description given by Prof. Smith, there is little doubt that they were the young of this insect.

The moth (Fig. 213) has reddish-orange fore-wings, crossed diagonally by numerous fine lines of a darker red-brown. There is also a broad, oblique, red-brown band across the middle of the wing, and a second of the same color extends to its tip, forming a triangular apical space; it is itself crossed by still darker brown lines; the hind-wings are pale yellow.



Fig. 213.—*Caccæcia parallella* Rob.

THE V-MARKED CACÆCIA.

(*Cacæcia argyrospila* Walk.).

This is also a common species which flies towards the end of June. Its caterpillar is a very general feeder, being found upon the rose, hickory, apple, oak, maples, elm, cherry, and even upon such plants as vetches. The colors of the moth vary considerably, but are usually a shining, pale, lemon-yellow, with a basal patch, central fascia and large costal spot rich, dark, velvety-brown. The spaces between the ordinary markings are clouded and speckled with dark brown, intermixed with ochraceous scales; fringes pale ochraceous. The hind-wings are dark fuscous. (Fig. 214, Plate VIII).

THE HICKORY LEAF-ROLLER.

(*Lophoderus juglandana* Fern.).

This insect has once been found flying among some young hickory and black walnut trees, and as it is known to be injurious to these plants, it is best to give a short description of it. The whole insect, with the exception of the lower wings, which are of a fuscous color, is dark reddish-

own; each of the fore-wings has two oblique, narrow bands of darker brown, and in the male there are scattered few scales of straw-yellow color, especially along the borders of the oblique bands.

THE APPLE LOPHODERUS.

(*Lophoderus trifera* Walk.).

This leaf-roller occurs on the apple, rose and on many other plants; it is very much smaller than *juglandana*. The fore-wings are pale reddish-brown within the central fascia; the internal margin is broadly covered at base with blackish-brown scales forming a rather prominent irregular spot. The central fascia is broad, distinctly dark-brown, sometimes reddish-brown. The sub-apical costal spot is dark-brown, and separated from the central fascia by a reddish-brown shade. The remaining outer portion of the wing is pale ochreous except a testaceous-brown spot above the anal angle; fringes dark ochreous.

THE RUSTY-BROWN TORTRIX.

(*Platynota flavedana* Clem.).

This insect feeds in its larval state upon the strawberry, raspberry, red and white clover. It is not very common, but is found from time to time in fairly large numbers, showing that it can under favorable conditions become injurious. The full grown caterpillar is about half an inch long, of a dark yellowish-green color, with the piliferous tubercles a little lighter and faintly polished. Head and thoracic-plate are reddish, first joint and anterior margin of the thoracic segment white; the anal-plate is concolorous with the body, sometimes a little lighter. There are three sky spots near the anterior margin of the anal-plate; the

tip of the segment has eight short and stiff bristles, and the whole body is covered with minute brown granulations. Early in September these caterpillars change to brownish pupæ with the usual short spines on the edges of the dorsal side of the abdominal segments. Soon afterwards the moths appear, of which the sexes differ considerably. The



Fig. 217.—*Platynota favedana* Clem.

males are of a dark-brown color over the larger part of the fore-wings, with minute tufts of scales over the surface; the outer portion and base of the wings are reddish-yellow; the hind-wings are dull rust-red. The females are dull rust-red, the fore-wings with three oblique bands across them, nearly obliterated in places. The expanse of wings in the male is five-eighths of an inch, that of the female three-fourths of an inch. (Fig. 217).

THE SULPHUR-COLORED TORTRIX.

(*Dichelia sulfureana* Clem.).

The caterpillars of this insect are rather general feeders; they are also found upon the leaves of the grape and the strawberry, which they draw together. Their home is most frequently arranged in such a manner that it forms a tube, open at either end; they feed upon the surrounding foliage, of which they devour only the under surface as long as they are still small, but later they eat irregular holes. Like most



Fig. 218.—*Dichelia sulfureana* Clem.

of such larvæ they are very active and escape from their tubes by suspending themselves by a silken thread, by which they can let themselves down to the ground and reascend to their shelters. The cylindrical caterpillar is slightly fusi-form; head and thorax are very pale honey-yellow, the rest of the body is yellowish-green with the ali-

ary canal showing dark green through the dorsum. piliferous tubercles are slightly paler than the rest of body, and each one is surmounted by a brownish hair. spiracles are green with a brown ring. Most of the pillars transform early in July to pupæ of a dark shiny brown; the moths issue soon afterwards. They are of a beautiful bright-sulphur and golden-yellow color, with a deep purplish red mark across each fore-wing, and more of the same color along the front border. They are with expanded wings about half an inch across. 218.

FAMILY GRAPHOLITHIDÆ OR GRAPHOLITHIDS.

These moths are readily distinguished from the other Tortricids by the presence of a fringe of long hairs on the outer part of the cubitus of the hind-wings. Nearly two-thirds of all our species of Tortricids belong to it.

THE GRAPE-BERRY MOTH.

(*Eudemis botrana* Schiff.).

This insect was imported many years ago into this country from southern Europe where it is very injurious. It is now very widely distributed in the United States, being probably wherever the grape is cultivated to any extent. It attacks all varieties of grapes, but is especially destructive to those with tender skinned berries or which are in compact bunches. It feeds also upon a number of other plants and can become such a very injurious pest that it has been known to destroy as much as 50 to 75 per cent. of the crop. In the more southern states it produces three annual generations, but only two farther north. The first generation of it is but rarely noticed, and no protective steps are taken; later in the season it can multiply with great rapidity, and it is apt to become decidedly injurious to the grapes which are ripening late.

The young caterpillars injure the berries early in July, when the infested fruit shows a discolored spot where the larva has entered. When we open the berry we generally find in the pulp a long and thin larva of a whitish-green color. Besides feeding on the pulp it sometimes eats portions of the seeds, and if the contents of a single berry are not sufficient two or more are drawn together by means of silk, mixed with castings. Such injured berries begin to appear while the fruit is young and green, but they increase in numbers as they ripen. Infested berries resemble very much those that are afflicted by a disease called the Black Rot. The young larva is about an eighth of an inch long, has a black head and a blackish cervical-shield; its body is

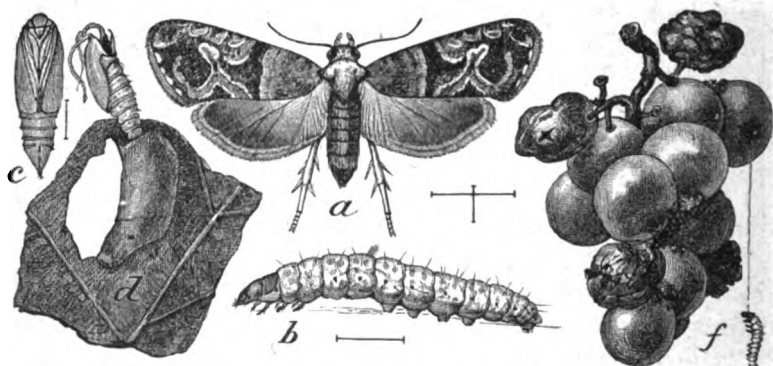


Fig. 219.—*Eudemis botrana* Schiff.; a, moth; b, larva; c, pupa; d case with empty pupa. all enlarged; f, grapes with worm natural size. From Div. of Entomology, Dep. of Agriculture.

dull whitish or yellowish-green. It is always very active and is apt to wriggle out of the grape and escape. When full grown it is about one-third of an inch long, and is now olive-green or dark-brown. At this time it abandons the berry, and now cuts out of the grape-leaf a little flap, which it folds over and fastens with silk, thus forming a small oblong case, in which it changes to a yellow or yellowish-brown pupa. Sometimes the larva simply rolls over a piece of the edge of a leaf and thus forms a retreat, which it lines with silk. The moth measures with expanded wings nearly

cenths of an inch across. Its fore-wings are of a slate-
or of a pale dull bluish shade, with a slight metallic
e, and ornamented with dark reddish-brown bands and
; the hind-wings are dull brown, deeper in color
rds the margin; the body is greenish-brown. The last
ation of larvæ remains in their leaf-cases through the
er, and emerges early in the spring. This, the first brood
terpillars, feeds upon the leaves, tendrils and blossoms
e grape, there being not yet any berries to enter. All
s of this insect are shown in Fig. 219.

Mr. Marlatt writes in one of the late bulletins of the
of Entomology that: "the use of poisons is not practi-
except against the first brood, which develops on the
part of the vine, and here the result is doubtful, be-
it is more than likely to breed on a great variety of
e and spraying would not afford much protection.
ing the grapes as soon as the fruit sets will undoubt-
protect them from this insect, and at the same time from
Rot. Of greater practical value, especially in larger
ards, is the prompt collection and burning of all fallen
s in autumn, thus destroying the hibernating larvæ and
, and also the collection and destruction of diseased
wherever feasible. Early gathering and shipping or
sal of fruit otherwise is a particularly valuable step, as
ures the removal of the larva in the grapes from the
ard if not their destruction in wine making. All fallen
should also be gathered and destroyed."

THE APPLE BUD-WORM.

(*Exartema malana* Fern.).

This insect has been quite injurious in northern Illinois.
The young caterpillar after devouring the bud, fastens
leaf-stalk of one of the leaves growing near the tip to
side of the branch, and thus forms a sort of tunnel

between the leaf-stalk and the branch, in which it finds a shelter during the day, issuing from it at night to eat the leaf so secured. It is stated that if it has eaten this leaf it also devours the newly formed wood, even burrowing for a short distance into the twig. The tips of the infested twigs usually die back as far as the base of the first perfect leaf, where a new bud forms, which soon assumes the position of the one destroyed. As this new bud is late in starting, and never grows straight, the injury caused by these small worms interferes seriously with the growth of the trees, and also mars their beauty. As long as young the caterpillar is pale greenish, or yellowish-green, sometimes tinged with pink on the back. It has a yellowish head, with a black dot on each side; the cervical-shield is also yellowish. When full grown it measures about half an inch in length and it is now of a dark flesh color; its body is marked with a number of small shining spots, and the head and horny cervical-shield are black. When about full grown it deserts the tunnel on the twig and constructs a yellow woolly tube or case upon one of the leaves, in which it lives, issuing at night to feed upon the neighboring leaves; if it has to move it drags its case along. Soon afterwards it closes the house with a silken door and transforms inside to a pupa, from which the moth issues in about ten days.

There is but one annual brood of this insect. Its forewings are white, mottled and spotted with greenish-brown; there is a large grayish-brown spot at the tip, mottled with white, and another towards the base of the wing, of a darker shade; the front edge is mottled with grayish-brown; the hind-wings are dusky.

The insect has as yet not been found in our state, but very likely it has been over looked. It can be kept in check by the proper use of Paris-green or London-purple mixed in the proportion of one teaspoonful of the poison to two gallons of water. Hand-picking is also a great help, and most of these insects can be gathered while still in their burrows

the tip of the twigs. Wherever the spraying of orchards noticed the insect can not become very numerous and active.

THE RASPBERRY LEAF-ROLLER.

(*Exartema permundana* Clem.).

This insect has received a number of other popular names, which indicate its food habits; it is called in southern England the *Hickory Exartema*, because it feeds on the leaves of the hickory. Prof. Saunders calls it the *Neat Raspberry Leaf-roller*. He says: "This pernicious little larva appears just about the time that the strawberry plants are opening, and delights to form its protecting web by drawing the flowers and flower-buds together into a ball, and to feast upon their substance, a peculiarity which renders its attacks much more injurious than any mere consumption of leaves would be. The larva is of a green color; with the head and upper part of the next segment black. When full grown it is about five-eighths of an inch long, is very active in its habits, and wriggles itself quickly



Fig. 221. — *Exartema permundana* Clem. After Saunders.

in its hiding place when disturbed. Late in June or in July it changes to a brown chrysalis, from which a few days the perfect insect escapes.

The moth which is shown magnified in Fig. 221, has fore-wings yellowish or greenish-brown, varying much in color, with irregular lighter markings crossing the wings obliquely; the hind-wings are ashy-brown.

The caterpillar is very destructive in some districts, and upon the wild strawberries as well as on the cultivated varieties."

Dr. Packard says that "from eggs laid the previous autumn on the twigs of hickories, the insect being probably double brooded, the caterpillars hatch out simultaneously with the opening of the leaves in spring, living about a week or ten days in this state between the folded leaves or rolling them up sideways or from the apex to the base; in the fold or roll thus made, which it lines with silk, it changes to a chrysalis, remaining about a fortnight in this state until in the third week in June, in southern New England, it appears as a beautifully marked moth flying about and resting on the leaves."

The caterpillars of this insect are rather general feeders, being found, besides on the plants already mentioned, upon the Siberian crabapple, raspberry, wild and cultivated blackberry, hazel-nut and Spiræa,

THE CRANBERRY-WORM.

(*Rhopotota vacciniana* Pack.).

Wherever this insect is common it causes great injury to the foliage of the cranberry vines and on that account is frequently called the "fire-worm." It has not been reported from our state, but doubtless occurs here. The moth (Fig.



Fig. 222.—*Rhopotota vacciniana* Pack.

222) is of a dark ash-color; the fore-wings are whitish, dusted with brown and reddish scales, with narrow white bands on the front edge, alternating with broader yellowish-brown bands, five of which are larger than the others, and from four of these, distinct but irregular lines cross the wings. The tips of the fore-wings are dark-brown and very pointed; the hind-wings are dusky gray. In the cranberry bogs of New Jersey they are very numerous during the month of June, when eggs for a second generation

deposited, the caterpillars of which appear early in July, preceded by the perfect insect, which deposits the eggs that remain dormant until the following spring.

The caterpillar is green, with a few hairs scattered over the surface of its body. Like other leaf rollers it feeds upon tender growing shoots, drawing the leaves together, binding them with silken threads and concealing itself in the enclosure. As soon as full grown it spins a slight web, either among the leaves on the vine or among leaves and rubbish on the ground, and there changes to the pupal stage, which lasts from ten to twelve days.

All cranberry insects can be largely destroyed by flooding the bogs at the proper time; the vines should be kept under water for two or three days, which will kill all insects injured by it. Where this remedy can not be applied we are to use the arsenical poisons.

THE APPLE LEAF-SEWER.

(*Phoxopteris nubeculana* Clem.).

This oddly marked moth (Fig. 223) is white, with brown markings. It deposits its eggs in June, and the caterpillar appears throughout the summer and autumn on apple leaves.

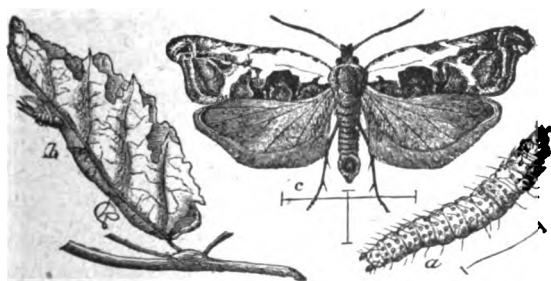


Fig. 223.—*Phoxopteris nubeculana* Clem. After Riley.

Like all leaf-rollers it folds the leaves together so that the edges meet, thus forming of the whole leaf a hollow case, in-

side of which it hides and feeds. The caterpillar is greenish-yellow, with a yellow head and a little darker horny cervical-shield, with a black dot on each side. On each of the remaining segments are a number of pale, shining, raised dots, from every one of which arises a single hair. As soon as the worms are full grown, on the approach of winter, they line their shelters with silk and fall with the leaf to the ground; they do not change to a pupa, which is yellowish-brown, until early in the following spring. When the enclosed moth is ready to emerge the pupa wriggles its way through the partly decayed case and thus gives the moth a chance to escape.

This insect is by no means a stranger in our orchards and nurseries and it has been known to become so numerous as to seriously injure the foliage of apple-trees. The burning of all leaves and other rubbish is in this case also an excellent remedy.

THE STRAWBERRY LEAF-ROLLER.

(*Phoxopteris comptana* Froel.).

This is the Strawberry Leaf-roller par excellence, though other leaf-rollers also attack the leaves of this plant. This insect is sometimes very common, causing in some seasons considerable damage. The moth appears early in July; it has reddish-brown fore-wings, spotted with black and white; the hind-wings are dusky, the head and thorax reddish-brown. It measures with expanded wings nearly half an inch across. The eggs for a second brood are deposited during the latter part of July, and the resulting caterpillars are full grown towards the end of September, when they pupate. They hibernate in this condition, and produce moths the following spring.

The caterpillars roll the leaves into cylindrical cases, secured by threads of silk; they feed inside these shelters and

the leaves to become discolored and to wither. They are a length of about one-third of an inch, and vary in color from yellowish-brown to dark-brown and green. Their heads are horny, of a yellowish color, with a dark, triangular spot on each side. The cervical-shield is colored and patterned like the head; on every other segment are a few pale hairs from each of which arises a single hair. The insect is shown in Fig. 224.

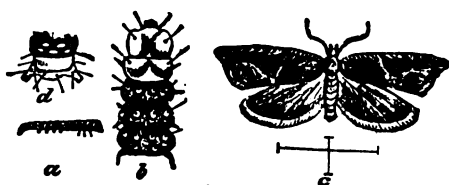


Fig. 224.—*Phoxopteris comptana* Froel. After Saunders.

The best remedy against this pest is to mow the plants and to burn them as soon as the fruit has been gathered. In planting we should be careful and select only plants from districts not infested with such injurious worms.

THE APPLE BUD-MOTH.

(*Grapholitha prunivora* Walsh).

This insect, which infests not alone the apple, but also plum and cherry, is not common in our state, and it is a new thing for our fruit growers that such is the case, as they become decidedly destructive by eating the buds of apple before they expand, thus causing much more injury than if the leaves themselves were eaten. The larvæ of this insect have also the bad habit of feeding inside cherries, which usually drop in consequence.

THE CODLING MOTH.

(*Carpocapsa pomonella* Linn.).

It may seem that a discussion of this insect is not necessary since it has received such very extensive attention at different times, and especially within the last few years. The discovery of a method of protecting orchards from their ravages, however, only make it more desirable that the life-history of the insect should be known in order that the remedies may be properly applied.

The insect is double-brooded in most of the apple-growing regions. The adult moth issues from the pupal stage shortly after or about the time of blossoming of the fruit trees, and deposits its eggs in the calyx of the newly forming

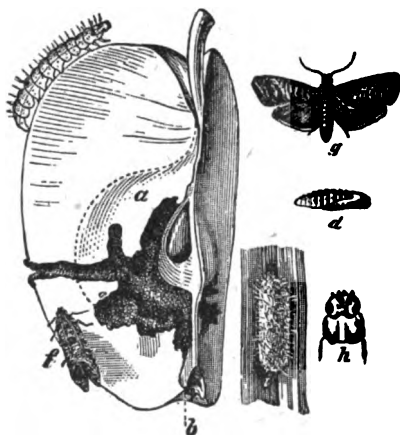


Fig. 226.—*Carpocapsa pomonella* Linn. After Riley.

apple. It has been shown, however, that in some cases the egg may be deposited elsewhere, even upon leaves. Soon after hatching the larvæ enter the fruit and attain their growth within, becoming mature about the first of July, when they leave the apple and seek a shelter such as crevices in the bark or rubbish on the ground in which to transform.

pass through the pupal state in about two weeks, and moths issuing about this time deposit eggs for the second d. The worms developing from these are found in the and early winter. Upon leaving the apple these larvæ their cocoons in the cracks of barrels and bins, or near s where the apples are stored.

The most successful method yet found of destroying insects consists in spraying the trees with a poisonous ion shortly after the fall of the apple blossoms; its suc depends upon the poison being retained within the calyx e apple until the time of hatching of the larvæ, and upon obtaining for their first food some of the poison thus ned. For this spraying London-purple is in some ets the most satisfactory material and should be used e rate of one and one-half pounds to one hundred gal- of water; it becomes more efficient if a small portion of or flour has been mixed with it. The powder should st made into a batter, after which it may be mixed with ll quantity of water required. The spraying should be with a force-pump and a nozzle which will give a fine that will settle upon all parts of the tree, and should be nued until the leaves begin to drip. Of the nozzles aufactured for this purpose there are several efficient s, which may be secured from manufacturers or through ware dealers. This spraying should be repeated within y days if there has been a shower of rain and it is con- ed wise to spray a second time eight or ten days later if there have been no showers.

has been determined by careful experiment that nearly ty per cent. of the fruit that would otherwise be infest- n be kept free of the worms by the use of this method; considering its cheapness and the ease with which it can plied even in large orchards it is worthy of general adop-

Prof. Saunders in "Insects Injurious to Fruits," a book should be in the hands of every fruit-grower, writes:

"This is one of the most troublesome insects with which fruit-growers have to contend, and although of foreign origin, having been imported from Europe about the beginning of the present century, it is now found in almost all parts of North America, entailing an immense yearly loss upon apple-growers.

"The early brood of moths appear on the wing about the time of the opening of the apple blossoms, when the female deposits her tiny yellow eggs singly in the calyx or eye, just as the young apple is forming; in a few instances they have been observed in the hollow at the stalk end, and occasionally on the smooth surface of the cheek of the apple. In about a week the egg hatches, and the tiny worm at once begins to cut through the apple to the core. Usually its castings are pushed out through the hole by which it has entered, the passage being enlarged from time to time for this purpose. Some of the castings commonly adhere to the apple, hence before the worm is full grown infested fruit may generally be detected by the mass of reddish-brown exuviae protruding from the eye. Sometimes as the larva approaches maturity it eats a passage through the apple at the side, as shown in the figure, and out of this opening thrusts its castings, and through it the larvæ when full grown escape. The head and upper portion of the first segment of the young larva are usually black, but as it approaches maturity these change to a brown color. The body is of a flesh-color, or pinkish tint, more highly colored on the back; it is also sprinkled with minute, elevated points, from each of which arises a single fine hair.

"In three or four weeks from the time of hatching the early brood of larvæ attain full growth, when the occupied apples generally fall prematurely to the ground, sometimes with the worm in them, but more commonly after it has escaped. The larvæ, which leave the apples while still on the trees, either crawl down the branches to the trunk of the tree, or let themselves down to the ground by a fine

thread, which they spin at will. In either case, whether they crawl up or down, the greater portion of them find their way to the trunks of the trees, where, under the bark and in cracks and crevices, they spin their cocoons.

Having selected a suitable hiding place, the larva constructs a papery-looking silken cocoon, shown in the figure. It is white inside, and disguised on the outside by attaching to the silky threads small fragments of the bark of the tree or other available debris. After the cocoon is completed, the change to the chrysalis takes place in the early part of the summer, in about three days. At first the pupa is of a pale green color, deepening in a day or two to pale brown; the pupa remains in this condition about two weeks, when the adult escapes.

Each moth is capable of laying on an average probably more than fifty eggs, but these are not all matured at once. By careful dissection they may be found in the body of the pupa in different stages of development. Hence they are hatched successively, extending over a period of probably one to two weeks or more; add to this the fact that some of the moths are retarded in their development in the pupa, and it is easy to account for the finding of larvæ of various sizes at the same time; indeed sometimes the later broods from the first brood will not have escaped from the pupa before some of the young larvæ of the second brood appear. Their appearance, the broods thus, as it were, overlap each other, and very much extending the period for the appearance of the winged insects.

The moth, although small, is a beautiful object. The forewings are marked with alternate irregular, transverse streaks of ash-gray and brown, and have on the inner angle a large, tawny-brown spot, with streaks of light green or copper color, nearly in the form of a horse shoe; at a distance they resemble watered silk. The hind-wings are of a light yellowish-brown, with the lustre

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of satin. The moth conceals itself during the day-time, and appears only at night, and, since it is not readily attracted by light, is seldom seen. The second brood of moths are usually on the wing during the latter half of July, when they pair, and in a few days the female begins to deposit her eggs for the latter brood of larvæ, generally selecting for this purpose the later apples. These larvæ mature during the autumn or early winter months; if they escape before the fruit is gathered, they seek some sheltered nook under the loose bark of a tree or other convenient hiding-place; but if carried with the fruit into the cellar, they may often be found about the barrels and bins in which it is stored; a favorite hiding-place is between the hoops and staves of the apple barrels, where they are found sometimes by hundreds. If thus provided with winter quarters and through negligence allowed to escape, the fruit grower must expect to suffer increased loss from his want of care. Having fixed on a suitable spot, the larva spins its little tough cocoon, firmly fastened to the place of attachment and within this it remains in the larval state until early the following spring, when it changes to a brown chrysalis, and shortly afterwards the moth appears, to begin the work of the opening season.

"Besides injuring the apple, it is very destructive to the pear; it is also found on the wild crab, and occasionally on the plum and peach. Sometimes two larvæ will be found in the same fruit.

"REMEDIES.—One of the most effective methods yet devised for reducing the numbers of this insect is to trap the larvæ and chrysalids and destroy them. This is best done by applying bands around the trunks of the trees about six inches in width; strip of old sacking, carpet, cloth, or fabric of any kind will serve the purpose, and although not so durable, many use common brown paper. Whatever material is used it should be wound entirely round the tree once or twice and fastened with a string or tack. Within such

asures the larvæ hide and transform. The bands should be applied not later than the 1st of June, and visited every ten or ten days until the last of August, each time taken down and examined, and all the worms and chrysalids found under them destroyed; they should also be visited once after the crop is secured. Some persons prefer to use narrower bands, not more than four inches wide, and fasten them with a tack, while others secure them in their place by simply tucking the end under. Usually the cocoons under the bands are partly attached to the tree and partly to the bandage, so that when the latter is removed the cocoon is broken asunder, when it often happens that the larva or chrysalis will fall to the ground, and if it escape notice may there complete its transformations. Wide mouthed bottles partly filled with sweetened water, and hung in the trees, have been recommended as traps for the codling moth, but there is no evidence that any appreciable benefit has ever been derived from their use. A large number of moths can be captured in this manner, but it is rare to find a codling moth among them. Neither is the plan of lighting fires in the orchard of much avail, since codling moths are rarely attracted by light. Spraying the trees soon after the fruit has set, and while it is still in an upright position, with a mixture of lime-green and water in the proportion of a teaspoonful to a pint of water, will deter the moths from placing their eggs on the apples, and thus protect much of the fruit from injury.

"The fallen fruit should be promptly gathered and destroyed. It has been recommended that hogs be kept in the orchard for the purpose of devouring such fruit, and where they can be so kept without injury to the trees or other crops they will no doubt prove useful.

"This insect, while in the larval state, is so protected within the apple that it enjoys great immunity from insect enemies. Nevertheless it is occasionally reached by the ever watchful Ichneumons, two species of which are known to

occur as parasites within the bodies of the larvæ. They have been bred by Mr. C. V. Riley, who describes them in his fifth Missouri Report. One is a small black fly, from one-fourth to one-half inch in length; its legs are reddish, the hind pair having a broad white ring. It is called the Ring-legged Pimpla, *Pimpla annulipes* Br. The other species is about the same size, but more slender, and of a yellowish or brownish color. The female is provided with a long ovipositor. This species is known as the Delicate Longsting, *Macrocentrus delicatus* Cresson. These useful insect friends are not yet sufficiently numerous to check materially the increase of the codling moth, and it is doubtful if they ever will be. When the codling worm has left the fruit in which it has been feeding, and while wandering about in search of a suitable spot in which to pass its chrysalis state, it is liable to be attacked by any of the Ground-beetles, (*Carabidæ*), both in their larval and their perfect state; also by the larva of Soldier-beetles and other carnivorous insects. Some of the smaller insectivorous birds are also said to devour this insect both in the larval and in the pupal condition."

THE EYE-SPOTTED BUD-MOTH.

(*Tmetocera ocellana* Schiff.).

This is also a very destructive insect, the larva of which eats into the opening bud of the apple, plum, cherry, blackberry and other plants. According to Prof. Fernald, who gave a full account of the life-history of this insect: "the moths pair and the female lays her eggs, when in confinement, in clusters of from four to ten or eleven, often overlapping each other. They are oval, flattened, four-fifths of a millimeter long, and half as wide, sordid white, with a narrow border of clear transparent white, while the center of the eggs is one complete mass of minute granules. In about three days the center of the egg has grown darker and

granules larger, and on either side there is a clear, white, al space about one-third the length of the egg. In about o days more the outer edge of the center is of the same or as in the last stage, and inside this is a narrow, lighter nd, while in the center is seen the form of a cylindrical va larger at one end, and both ends slightly curved wards each other; and in one or two days more the whole m of the larva is visible, the head, thoracic and anal eld being black. The egg stage lasts from eight to eleven rs.

"When the young larva hatches it does not eat the shell the egg, but goes on to the tenderest leaves, and almost mediate begins spinning a microscopic layer of silk, der which it eats the outer layer or epidermis of the leaf. e larva is then about three millimeters in length, of a creamy-white color, with head, thoracic and anal shields blackish-brown, and a few minute pale hairs on the body; the head is very large for the rest of the body. In a week the larva is nearly four millimeters long, light yellowish-brown, with the head, thoracic and anal shields dark-brown, and it eats minute holes through the leaf, its



227.—*Tmetocera cellana* Schiff.

ken web now being visible to the naked eye. The larva adually becomes a trifle more brownish, increases in size d enlarges its web along the side of the midrib.

"Late in fall the silken web is quite heavy and thick, d the larva deposits its excrements in little black pellets the form of a tube under the web, within which it hiber- tes during the winter. Not unfrequently two leaves are tened together by the silk of the web and sometimes a f is secured to a branch of the tree in the same manner.

"About the first of May the larva measures seven milli- ters when resting, and eight when in motion. It is indrical in form, with the head dark brown and of medium e. The body is dark yellowish-brown, and the head,

thoracic and anal shields very dark, polished brown. There are ten lighter brown protuberances on each segment, from each of which arises one pale hair. On the upper surface of the ninth segment is seen the double undeveloped reproductive organ of a light brown color. The legs are dark brown and the prolegs yellowish-brown. About the first of June the larva is from ten to twelve millimeters in length, and the body has changed to a cinnamon-rufous color. From the middle to the last of June it curls or draws together several leaves which it lines with silk, and in which it transforms to a pupa.

"The pupa is seven millimeters long, brownish-yellow, tapering from the head to the posterior end, with the wing-cases dark-brown. There are two rows of dark-brown spines pointing backwards, across each abdominal segment. The spiracles and anal segment are dark-brown. It remains in the pupa stage about two weeks and then the moth emerges.

"For some years past, I have observed the habits of this insect, and have been able to carry it through its transformations. The moths emerge between the last of June and the middle of July, though belated specimens are sometimes taken on the wing as late as the middle of August, and one was taken at this place August 25th, 1889.

"The fore-wings expand about three-fifths of an inch. The head, thorax, and basal third of the fore-wings, and also the outer edge and fringe are dark ash-gray, the middle of the fore-wings is cream-white, marked more or less with costal streaks. Just before the anal angle are two short, horizontal, black dashes followed by a vertical streak of lead-blue, and there are three or four similar black dashes before the apex, also followed by a streak of lead-blue.

"The hind-wings above and below the abdomen are ashy-gray. The underside of the fore-wings is darker, and has a series of light, costal streaks on the outer part.

"To destroy these caterpillars, it is desirable to gather

the leaves from under the infested trees in the fall and turn them, and also to shower the trees with one pound of Paris-green in one hundred and fifty gallons of water, in the spring when the buds first begin to swell."

Besides the Tortricidæ thus far described there are many others that are fond of the leaves of our cultivated fruits, but as all are similar in their modes of life, etc., it is not necessary to mention them, especially as the remedies that can be applied are also about the same.

SUPER-FAMILY TINEINA OR TINEIDS.

Tineids are all very minute moths, with narrow wings, bordered by wide fringes; only a few possess broader wings with narrow fringes. They are often very beautiful, their wings being covered with scales that shine like silver and gold, but their small size make it necessary to examine them with a lens to appreciate their beauty. Their larvæ feed usually upon or within the leaves of plants; others thrive within nuts, seeds and dried fruits; still others eat dead animal matter, as woolens, fur and feathers; while a few are predaceous, destroying scale-insects. Many species of such moths occur in the United States and nearly one thousand have already been described. The work of most of the mining species is very characteristic, and it seems that each one infests only a particular species of plant, in the leaf of which it makes a mine of definite shape, by means of which an expert can determine the species that made it. There are many leaves in late summer and autumn that do not show the signs of different kinds of Tineids. When we study such leaves we find that the little larvæ of the Tineids live until they are grown between the two skins of a leaf, deriving their nourishment from the green parenchyma.

THE PALMER WORM.

(*Ypsolophus pomotellus* Harr.).

According to Fitch this insect is in the state of New York more or less common every year, making its appearance towards the middle of June. In some years it becomes very numerous, and as it is a very general feeder the green foliage of the trees infested can in a single day change to a withered brown hue, as if scorched by fire. As long as the worms are still young they eat only the green pulpy tissues of the leaf,



Fig. 228.—*Ypsolophus pomotellus* Harr.
After Fitch.

leaving its net work of veins entire, but as they become larger they consume the whole of the leaf except the coarse veins. The young and tender leaves which grow at or near the tips, are preferred; the older and tougher ones are simply eaten at their tip ends, or have irregular holes of various sizes gnawed in

them, some of these holes not being larger than a puncture made with a pin. The green and soft ends of twigs are also eaten. They enjoy eating either round holes or large irregular cavities into young apples, which soon afterwards wilt and drop to the ground.

The caterpillars vary greatly in color. When full grown they measure almost half an inch in length, and are commonly pale-green or yellowish-green; along each side of the back is a dusky stripe and above this a faint, whitish one, and on the middle of the back is another dusky stripe between the white ones. There are also several small black spots, arranged symmetrically, and each yielding a fine hair; the polished head is yellow. These caterpillars change to pale tawny-yellow pupæ in the same tuft of leaves in which they resided; they make but a very slight cocoon.

The moths also vary greatly in coloration but the usual

color is ash-gray; the fore-wings are sprinkled more or less with black scales, and have on the apical edge at the base of the fringe six to seven equidistant black dots. On the disk there are also four larger black or brown dots, two before and two behind the middle, the latter nearer together than the former. The moth is shown in Fig. 228.

There are two other species of Palmer Worms, both found occasionally in our orchards. These are the Comstock Plum Worm (*Ypsolophus contubernalis* Fitch), and the Striped Palmer Worm (*Y. malifoliellus* Fitch).

In case these worms should become numerous they can be successively combatted by spraying the trees with any of the arsenical poisons; they are also readily dislodged by the use of whale-oil soap diluted with water.

THE STRAWBERRY ROOT-BORER.

(*Anarsia lineatella* Zell.).

This insect is not found alone on the strawberry plant, but it is also very destructive to the twigs of a number of trees. In the Eastern States it has the bad habit of boring into the tender twigs of the peach tree, killing the terminal buds, and in the western states it invades the young plum trees in a similar way. In Europe it is also destructive to the peach. It is an insect that can become very destructive to the strawberry plants. Its caterpillar is only about half an inch long, reddish-pink, fading into dull yellow on the second and third segments; the cervical-shield is smooth, horny, and of the same brownish-yellow color as the head. A few shining and reddish dots are found on each segment, from each of which rises a single, fine, yellowish hair. The under surface of the worm is paler. It bores irregular channels through the crown of the plant, sometimes excavating large chambers; at other times it tunnels it in various directions. If we examine such cavities or tunnels in spring

we will find in them a small, soft and silky case, almost filled with castings, which no doubt was the hibernating quarters of the worm. The caterpillars mature early in June, and transform into small reddish-brown pupæ, either inside the cavity of the crown of the plant or outside among decayed leaves or other rubbish.

The moth appears early in July; it is quite small, of a dark gray color, with a few blackish-brown spots or streaks on the fore-wings; the fringes on all wings are gray, tinged with yellow. Towards the end of July or early in August this moth deposits on the crown of the plant an egg which soon hatches. The small worm burrows at once into the heart of the plant, and after making a snug silken home it retreats into it for the winter. Both worm and adult are shown in Fig. 229.

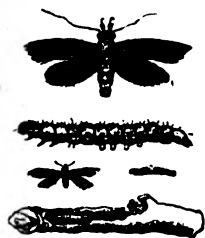


Fig. 229.—*Anarsia lineatella* Zell. After Saunders.

Many remedies have been proposed, but the only certain one is to dig up the infested plants and to burn them. If they infest trees these should be clipped as soon as the insects are discovered and the parts removed should also be burned.

It seems more than doubtful that the same insect should possess such different habits as eating into twigs of trees and boring into the crowns of strawberries, and closer investigation is needed to decide this question. Perhaps two species of insects resembling each other very closely cause these damages.

WILD CHERRY LEAF-MINER.

(*Ornix geminatella* Pack.).

The larva of this moth makes also a tentiform mine on the under surface of the apple leaves, eating the parenchyma,

d forming a pupa at the edge of the turned up leaf in a
 ken cocoon. The cylindrical larva reaches a length of
 out one-fourth of an inch; it is grayish, with a light
 own head and a light yellow first thoracic segment. On
 e dorsal surface of the rest of the body are four longi-

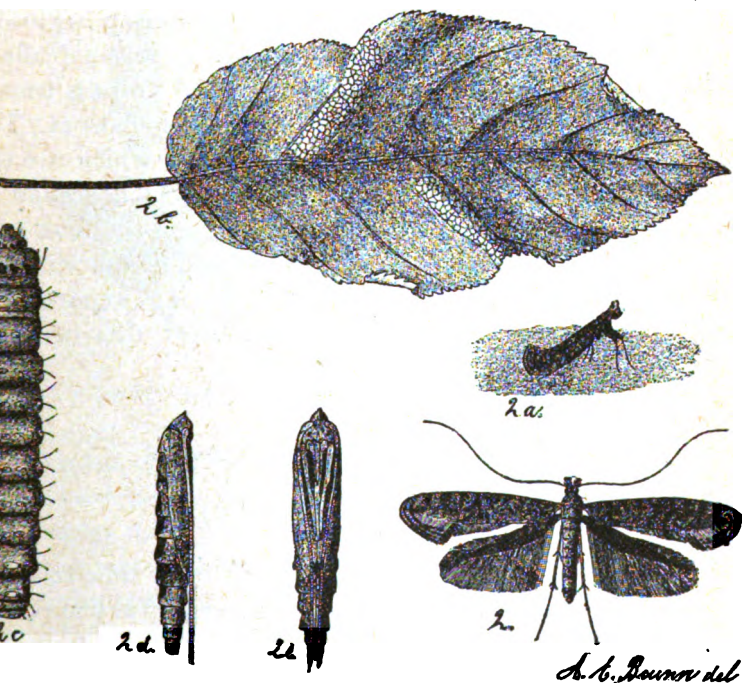


Fig. 230.—*Ornix geminatella* Pack. After Comstock.

dinal rows of white elevations, each segment having at or
 ar its middle one of these elevations in each row. Two
 nilar rows of elevations are found on each side of the
 va, and from each of these elevations arises a very long
 ir. Upon the back of the head are found conspicuous black
 ots; upon the cervical-shield are also larger black spots;
 e true legs are black on their outside while the inside is
 ayish. As soon as full grown the larva leaves the mine

through a small circular hole at one end, and folds the edge of the leaf over itself by means of silken threads and forms in this shelter a delicate silken cocoon. Here it changes to a pupa and hibernates. The pupa is brownish-yellow.

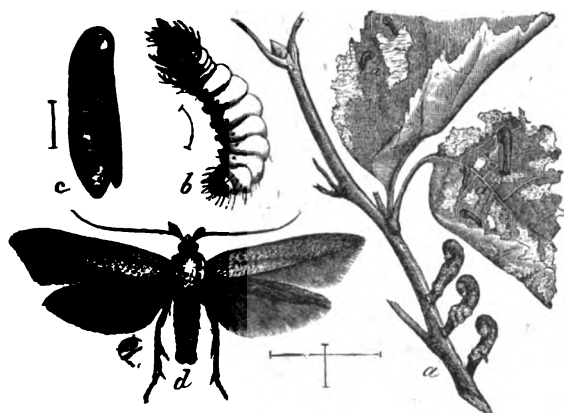
The moth is dark steel-gray, almost brown. The thorax and fore-wings are steel-gray, the latter with about nine faint, whitish, costal streaks, the first near the base and the last at the apex; all are faintly dark margined internally; the last three or four are nearly perpendicular to the costal margin, crossing the wing and uniting near the dorsal margin, where they are narrow and indistinct. There is also a small black apical spot, behind which are three dark hinder marginal lines in the fringes; a second one is at the middle, and a third at the apex and the first at the base of the fringes. The one at the base of the fringes becomes furcate in the dorsal fringes. The wings expand about one-third of an inch. All the states of this insect are shown in Fig. 230.

THE APPLE TREE CASE-BEARER.

(*Coleophora malivorella* Ril.).

These interesting insects are found from time to time in large numbers on the twigs of apple trees. They make curious pistol-shaped cases; which on examination will reveal the little architect inside; it is a minute larva of a pale-yellow color, with a faint rosy tint, a black head, and a few short hairs on its body. The cases, which the caterpillars carry always with them, are very tough, almost horn-like, and form a very safe protecting shelter. When at rest the caterpillars hoist these cases in the air, as shown in the illustration, Fig. 231, a. Similar cases are quite common on the white-oak. As soon as the buds of the apple-trees commence to swell these cases are found sticking to their outside, while the active little caterpillar is busily engaged in

bying the tender leaves enclosed in them. Many fruit-are thus destroyed, and nothing but their hollow shells in. Later in the season these active insects leave the and fasten their cases to leaves, from which they eat green pulp, so that nothing remains but a mere skeleton. after changing late in June to pupæ the moths appear,



231.—*Coleophora malivorella* Ril. From Div. of Entomology, Dep. of Agriculture.

deposit eggs, from which in the same season a new d of caterpillars hatches, which feed on the under side e leaves until the frost drives them to the twigs, to n they fasten very securely their little cases.

he minute moth, measuring a little more than half an across the wings, has brown wings with white scales; ead and thorax is white, the abdomen whitish, and all otted with brown scales.

GRAPE-VINE LEAF MINERS.

(*Antispilla spec.*).

here are a number of mines found in the leaves of the and cultivated grape-vines, as well as in the closely d Virginia-creepers. The minute caterpillars which

make these mines, form peculiar silken cases in which they pupate, and as these cases are of different shapes they are evidently made by different insects. A number of moths have been described which make these mines; they are: *Antispilla viticordifoliella* Clem., *A. ampeliopsiella* Cham., and *A. isabella*. These moths are very much smaller than their names, and do not occur in sufficient numbers to cause any serious injury. They are frequently parasitized, notwithstanding their apparently perfect protection by leaf and silky cocoon.

THE SPOTTED TENTIFORM MINE OF THE APPLE.

(*Lithocolletis cratægella* Clem.).

The caterpillar of this insect makes on the under side of an apple leaf a tentiform mine, which has the upper surface

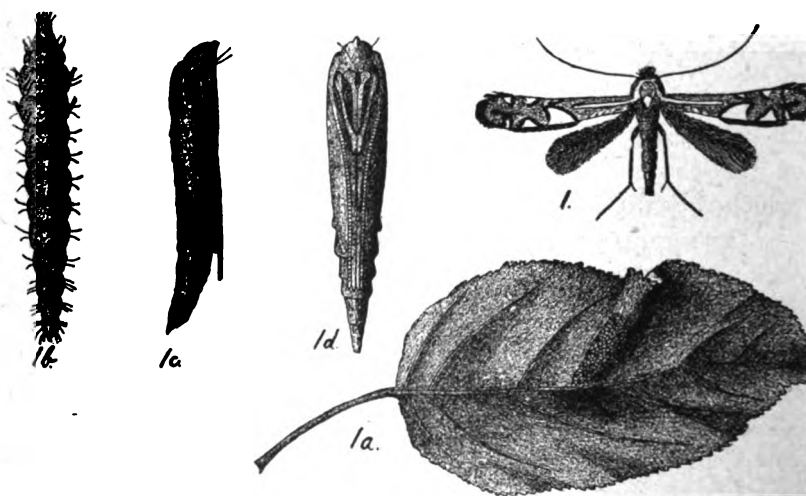


Fig. 282.—*Lithocolletis cratægella* Clem. After Comstock.

spotted and honey-combed. When we open such a mine early in September we discover in it a yellowish larva of a

dricular form, with a very long head, which is wedged, quite pointed and bilobed. The peculiar shape of larva is shown in the illustration, Fig. 232. It pupates at the end of the mine in a loose silken covering.

The moth has golden-brown fore-wings with white marks and spots. The face and lower side of antennæ are very white. There is a black apical spot. It expands three to five-sixteenths of an inch.

THE PEAR AND APPLE-TREE LEAF-MINER.

(*Lithocolletis geminatella* Pack.).

Among the numerous insects that mine the leaves of our pear, this insect becomes sometimes quite numerous, and the blotched and disfigured foliage plainly indicates its presence.

The worm is a very small being, of a pale reddish color, with a black head and cervical-shield. As a general rule it draws two leaves together, and unites them by means of strong silken fibres; at other times it folds up a single



Fig. 233.—*Lithocolletis geminatella* Pack. After Saunders.

During August the larva changes to a very long and slender pupa within the mine, and soon afterwards the perfect insect appears, which deposits the eggs for another year, which winters in the larval or pupal state inside the leaves. They can be materially reduced in numbers by gathering all the fallen leaves and by burning them. (Fig.

The moth expands about one-third of an inch across the wings. The fore-wings are dark-gray, with a round black-

ish spot on the middle of the inner edge of the wing; there is also an eye-like spot on the outer edge, with a black pupil.

Other species of *Lithocolletis* also mine in the foliage of the apple.

THE APPLE LYONETIA.

(*Lyonetia saccatella* Pack.).

This is a very minute and beautiful moth, measuring scarcely one-fifth of an inch across the expanded wings. It is not common, but some are found in early summer. Its wings are of a light slate-gray color on the basal half, while the outer half is bright orange, enclosing two white bands, one arising on the front edge, the other on the inner margin, both nearly meeting in the middle of the wing; these white bands are margined externally with black; there is also a



Fig. 234.—*Lyonetia saccatella* Pack. After Saunders.

conspicuous black spot near the fringe, from which arises a pencil of black hairs.

According to Saunders the small flattened and green larva feeds on apple leaves; it constructs from the skin of the leaf an oval and flattened case which forms its house. This case is open at each end, and is drawn about by the insect as it moves from place to place. When the insect reaches its full size it attaches this case or bag to the bark of the tree on which it had been feeding, transforms to a pupa, in which condition it passes the winter, giving forth the moth in the following spring. The insect is shown in Fig. 234.

THE APPLE-LEAF BUCCULATRIX.

(*Bucculatrix pomifoliella* Clem.).

The larvæ of this minute moth live exposed on the foliage of the apple trees. They are very active and as soon as disturbed let themselves down from the leaf by means of a silken thread. They reach a length of about half an inch and have dark yellowish-green bodies, the anterior portion colored with reddish; their heads are brown and a few short hairs are scattered over the surface of their bodies. As soon

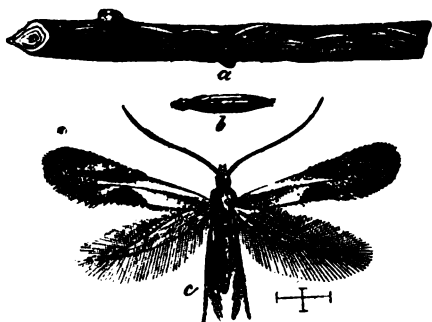


Fig. 235.—*Bucculatrix pomifoliella* Clem. After Riley.

when grown they spin an elongated whitish cocoon attached to the twig on the leaves of which they had been feeding. The cocoon is ribbed longitudinally; inside of it the pupa changes to a brown pupa. A second brood appears in autumn, the insect hibernating in the pupal state.

In the following spring the moths appear which deposit the eggs for the first brood of caterpillars abounding in the spring.

The moth is a very delicate being, of a whitish color, and dusted with pale-yellow and brown. On the inner margin of the fore-wings is a large oval spot of dark brown, forming when the wings are closed a conspicuous nearly round spot; there is also a wide streak of

the same color opposite, extending to the front margin, and a dark brown spot near the tip.

As this insect appears sometimes in very large numbers, coating the twigs with glistening white cocoons, it can become injurious, but as the very conspicuous cocoons can be seen very plainly during late autumn, winter and early spring there is ample opportunity to destroy them. Any oily or alkaline liquid brushed over them will soak into the cocoons and destroy the hibernating insects. Sometimes the great majority of these insects are destroyed by a very minute hymenopterous parasite, as is shown by the small round holes at one end of the cocoons through which our tiny friends have escaped. The insect is shown in Fig. 235.

THE APPLE-LEAF MINER,

(*Tischeria malifoliella* Clem.).

This common insect lives as a larva within the leaf of the apple, in a mine made between the upper and lower skin, where it eats the soft tissues. The mine commences as a slender white line, broadening as the larva grows larger, and at last becoming an irregular brownish-patch, which extends sometimes to or over the starting point. The inhabitant of this mine is a pale-green caterpillar with a brown head and first segment. When full grown it draws the leaf into a fold, and in this enclosure, which is nicely carpeted with silk, it changes to a pupa. As this change takes place in autumn the snugly enclosed insects drop with the dead leaves, and remain in them until the following May, when they give forth the moths. This is a very minute being, measuring not much more than a quarter of an inch across the expanded wings. The fore-wings are of a shining dark brown, suffused with a tinge of purple, and slightly dusted with dull yellowish atoms; the hind wings are gray.

Besides the common apple this caterpillar mines in the

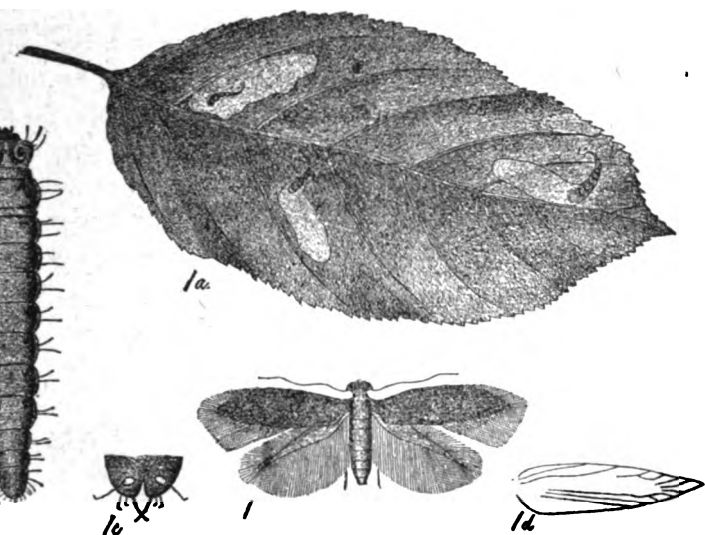


Fig. 236.—*Tischeria malifoliella* Clem. After Comstock.

s of the crab-apple, of the blackberry and the raspberry, but is not found in sufficient numbers to do any material injury. It is illustrated in Fig. 236.

THE RESPLENDENT SHIELD-BEARER.

(*Aspidisca splendoriferella* Clem.).

This interesting insect is sometimes found in Minnesota, thus far only in very limited numbers. Its life-history is known. The minute but very beautiful moth is found in May; it has a golden head; the antennæ are brown, and with gold; the fore-wings from the base to the middle of a leaden-gray with a metallic lustre, and from the middle to the tip golden; a broad silvery streak extends from the front edge to about the middle, margined with a dark brown on both sides; there are also other streaks and spots very or dark brown. The hind-wings are of a rich deep brown, margined with a long yellowish-brown fringe. These

beautiful creatures enjoy the sunshine, and are frequently found running about the surface of the apple leaves; during these active movements, which almost look like dancing, they have their wings closely folded to the body, as if afraid their fine dresses might become soiled. They deposit their eggs on the apple leaves, and the young larva as soon as hatched penetrates to the interior of the leaf, where it forms a mine, leaving both surfaces of the leaf intact, but forming

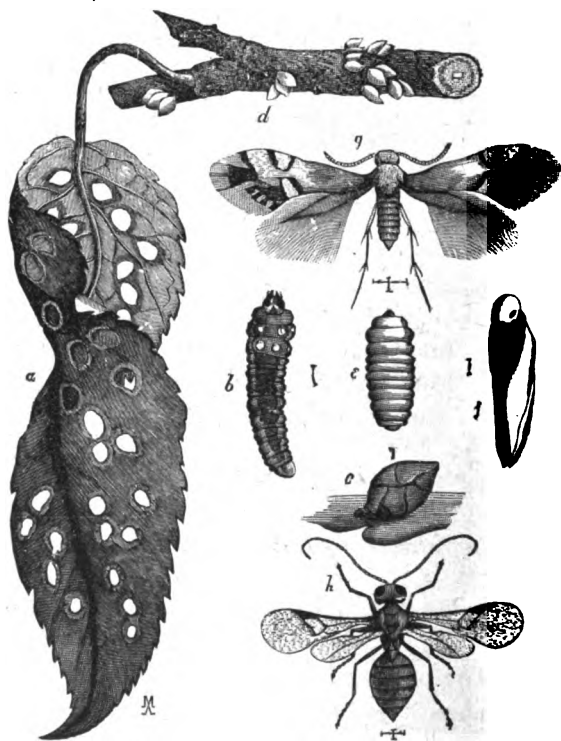


Fig. 237.—*Aspidisca splendoriferella* Clem. From Div. of Entomology, Dep. of Agriculture.

after a time an irregular dark colored blotch upon the leaf. The peculiar looking larva, which is like all leaf-mining larva quite flat, is about one-eighth of an inch long, and of a yellowish-brown color, with a dark head. As the time

es in which it has to transform to a pupa, it constructs parts of the leafy blotch a neat little case, and crawls with it to a twig it fastens the case securely to it. It contracts inside this shelter and finally transforms to a . The different states of this little beauty are shown in 237.

There are two annual broods, the latter hibernating in little houses just mentioned.

Though so very small the insect can increase very rapidly in numbers and become injurious to our apple trees. If it happens the cocoons, which can readily be detected, should be removed or should be soaked with an alkaline solution or a mixture of sulphur and lime. This mixture, which is also good for various other insects, is made by mixing five pounds of fresh lime with one pound of sulphur and ten gallons of water, and heating until the sulphur is dissolved.

THE BLACKBERRY LEAF-MINER.

(*Nepticula rubifoliella* Zell.).

This is a minute species the adult of which is described as follows: Head dark luteous. Palpi somewhat paler luteous. Antennæ luteous, basal joint silvery white. Forewings blackish-brown, with a rather narrow, curved, silvery band about the middle of the wing. The band is concave toward the base of the wing and shows a tendency to be interrupted in the middle. Fringes whitish. Hind-wings whitish, fringes the same.

Of the larva Dr. Clemens makes the following statement: The larva mines the leaf of the blackberry in September. It makes a blotch mine on the upper surface of the leaf, beginning as a slender gallery, extending quite a distance, finally along a vein of a leaf before being enlarged into a chamber. The body of the larva tapers posteriorly, the ter-

minal rings being attenuated; color pale-green with a bright dark-green vascular line; head greenish-brown and small. The larva was not taken from the mine for description. It leaves the mine very early in October to spin an oval, very dark reddish-brown cocoon and appears as an imago during the latter part of May or early in June. There is therefore, in all probability, a summer brood, which may be found in July and August, if the conjecture is correct."

THE CASE-BEARING BLACKBERRY LEAF-MINER.

(*Nepticula villosella* Clem.).

The larvæ of this species occur in the leaves of the blackberry during the latter part of June to the middle of July. The mine is very narrow, only about wide enough to accommodate the miner, tortuous, with a central frass line. The larva is pale brownish, and leaves the mine during the latter part of July. It differs from the above insect both in the shape of the mine and in the color of the larva.

As is usual when a leaf-mining larva has attained a certain age it cuts out the two skins of the mined place and constructs of it a portable case, which it never abandons subsequently, except to construct a new one when its increase in growth demands such a change. In feeding the larva attaches its case to a leaf, and bores into it between its skins, eating out a transparent patch, extending its body from the case for this purpose, but quickly retreats into it again if alarmed.

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LABOR SCIENCE



Parasitic Insects destroying caterpillars and pupæ. From Gartenlaube.

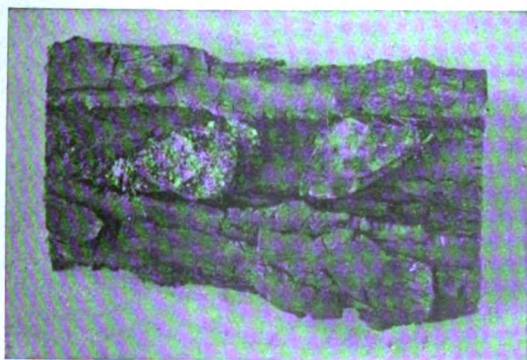
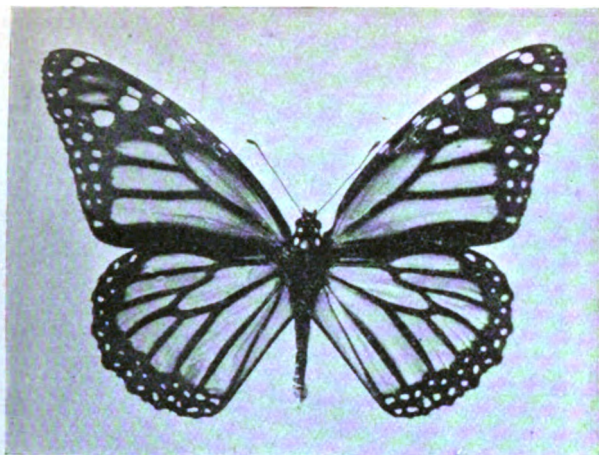


Fig. 4.—*Danaus archippus* Fab.

Fig. 5.—*Limenitis dalippus* Gdt.

Fig. 2.—*Marmoptery gibbicostata* Walk., resembling bark.

PLATE II.

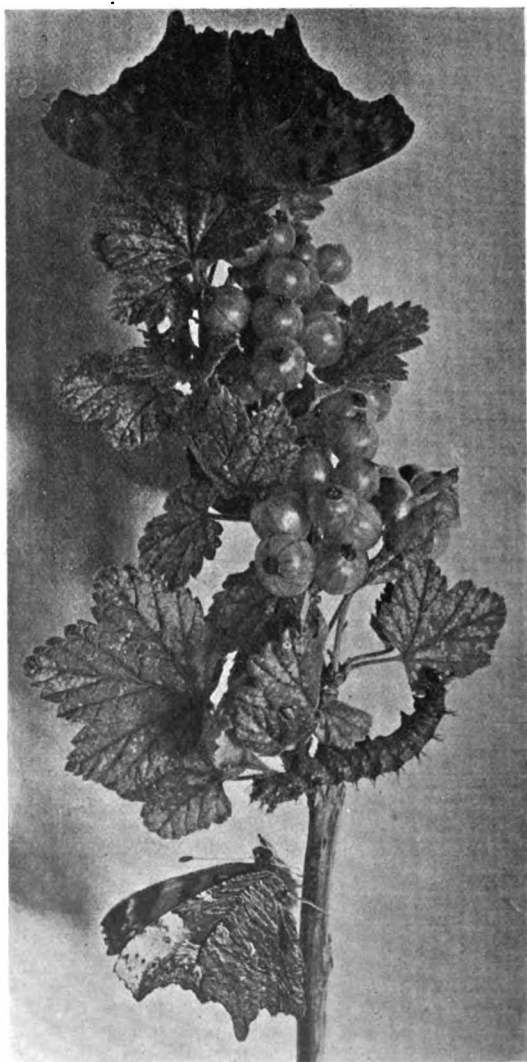


FIG. 17.

Fig. 17.—*Grapta comma* Harr., showing two butterflies, caterpillar and empty chrysalis.

PLATE III.

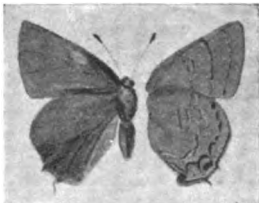
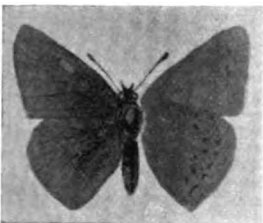
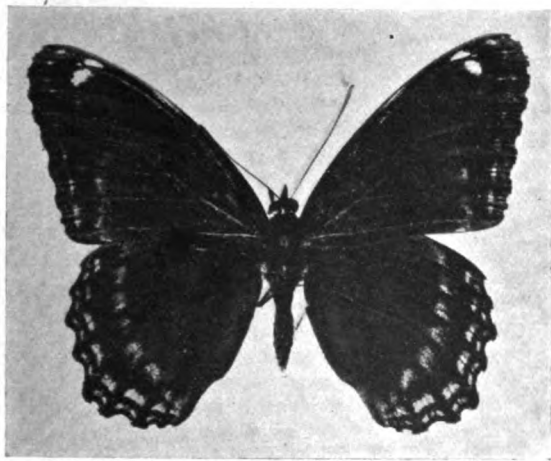
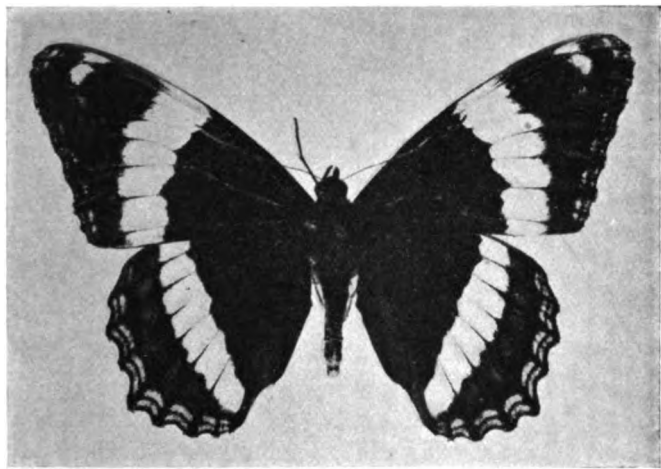


FIG.
24.

21.—*Limenitis arthemis* Dru.
22.—*Limenitis ursula* Fab.

Fig. 23.—*Thecla titus* Fab.
Fig. 24.—*Thecla calanus* Hub.

FIG. 27.

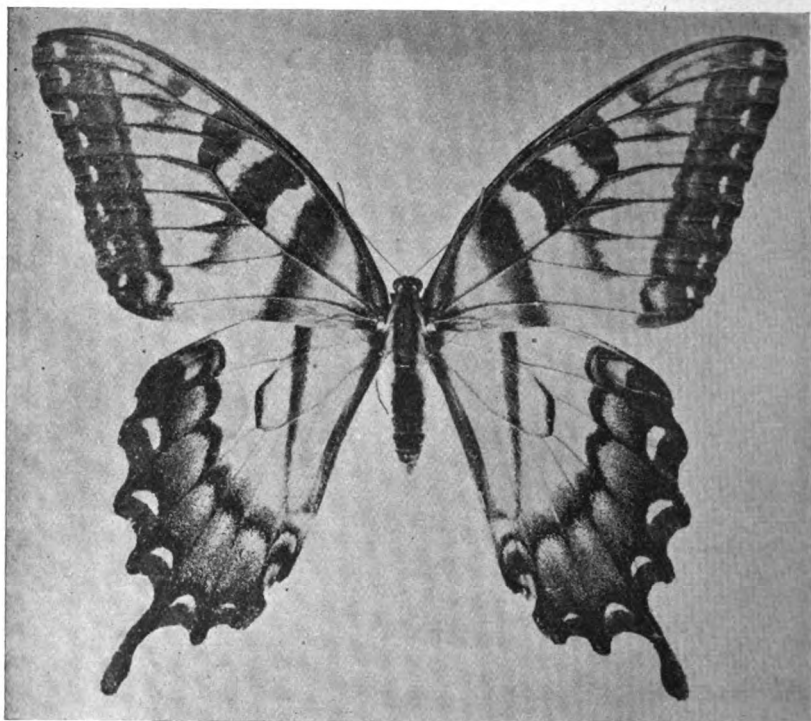


FIG. 29.

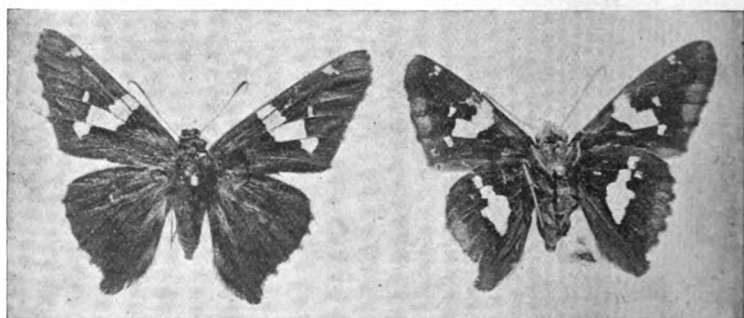


FIG. 108

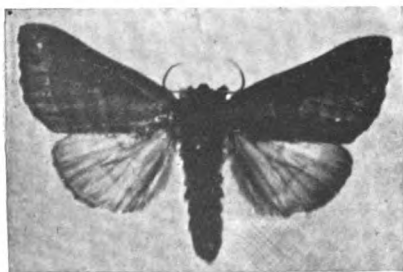


Fig. 27.—*Papilio turnus* Linn.
Fig. 29.—*Eudamus tityus* Fab., both sides.



Fig. 107.—*Datana integrissima* G. & R.
Fig. 108.—*Datana contracta* Walk.

PLATE V.

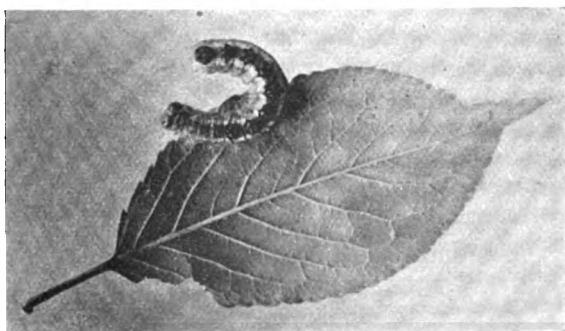
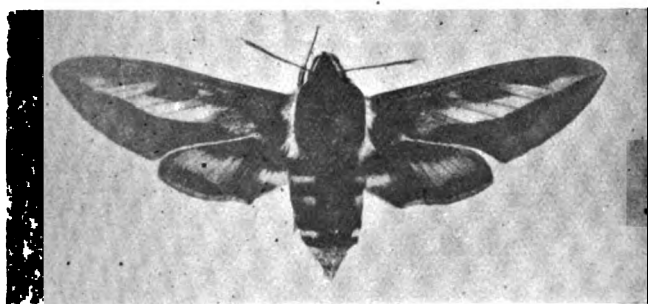
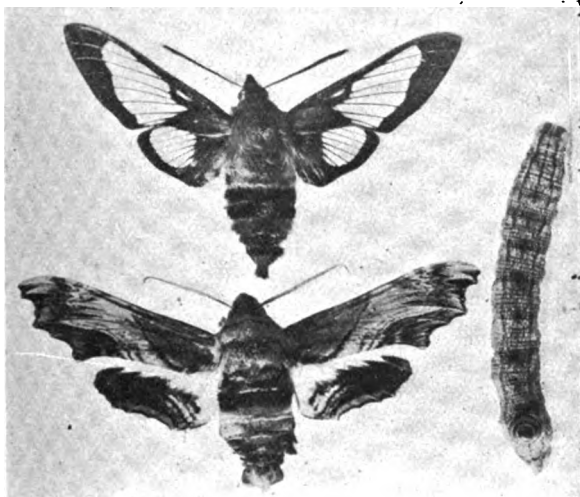


Fig. 30.—*Hemaris thysbe* Fab.
Fig. 32.—*Thyreus Abbottii* Swains. and larva.
Fig. 37.—*Deilephila gallii* var *chamænerii* Harr.
Acronycta caterpillar on leaf of plum.

FIG. 43.



FIG. 36.



FIG. 48.

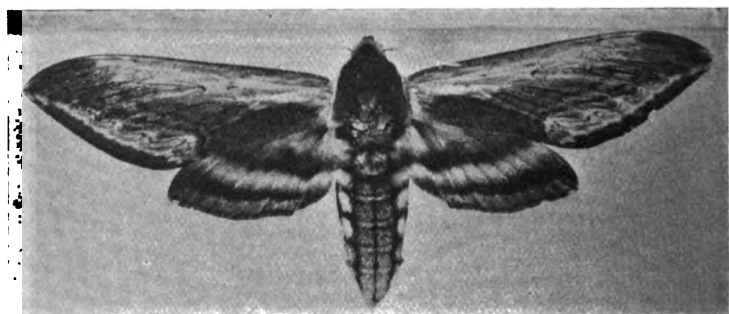


FIG. 51.



Fig. 43.—*Ampelophaga myron* Cram. and pupa.

Fig. 36.—*Dellephila lineata* Fab. and larva.

Fig. 48.—*Sphinx drupiferarum* S. & A.

Fig. 51.—*Sphinx gordius* Cram.

PLATE VII.

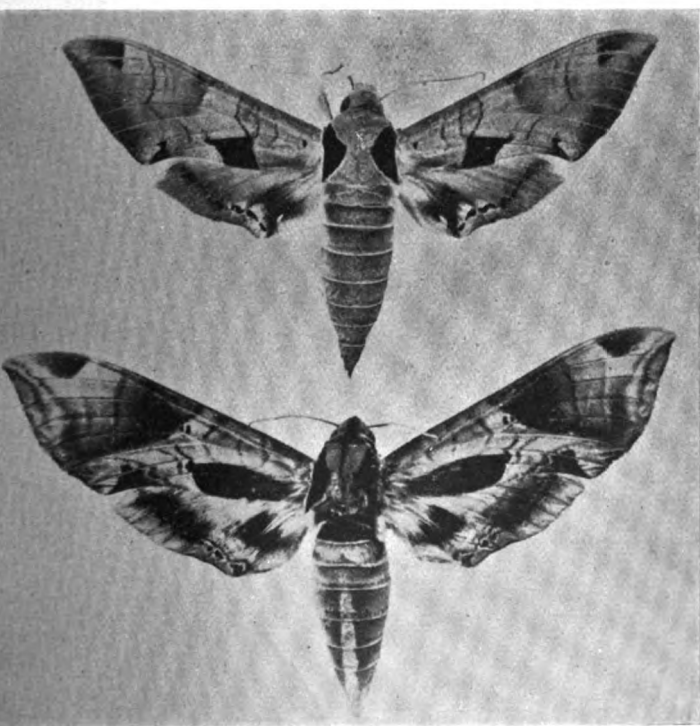
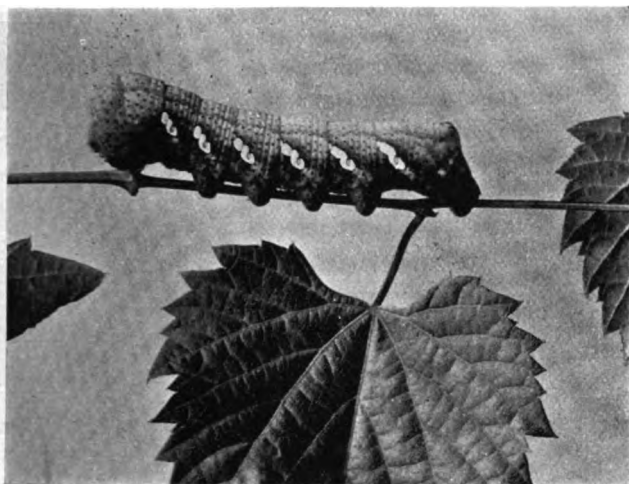


Fig. 39.—*Phyllampelus achemon* Dru., larva.
 Fig. 40.—*Phyllampelus achemon* Dru.
 Fig. 42.—*Phyllampelus pandorus* Hbn.

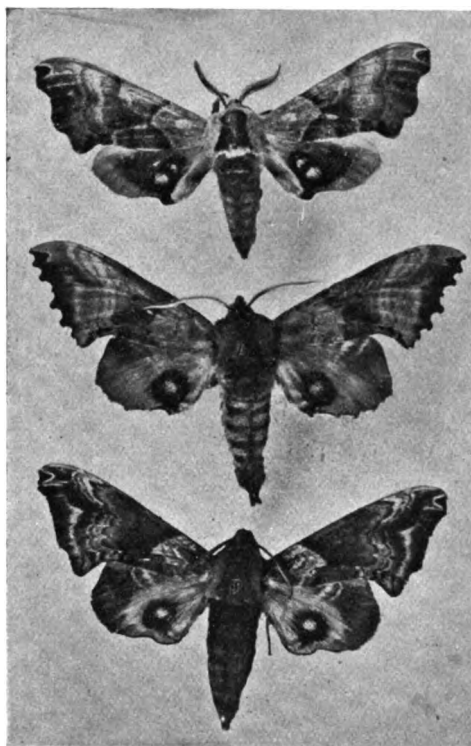
FIG.
56.FIG.
53.FIG.
54.FIG.
57.FIG.
132.

FIG. 164.



FIG. 169.



FIG. 211.



FIG. 212.



FIG. 21.

Fig. 53.—*Paonias excrucatus* S. & A.
Fig. 54.—*Paonias myops* S. & A.
Fig. 56.—*Smerinthus geminatus* Say.
Fig. 57.—*Cressonla juglandis* S. & A.
Fig. 132.—*Hemilleuca mala* Drury.

Fig. 164.—*Chamyris cerintha* Tr.
Fig. 169.—*Nolaphana malana* Fitch.
Fig. 211.—*Cacoccia rosaceana* Harr.
Fig. 212.—*Cacoccia cerasivorana* Fitch.
[Fig. 214.—*Cacoccia argyrospila* Walk.

PLATE IX.

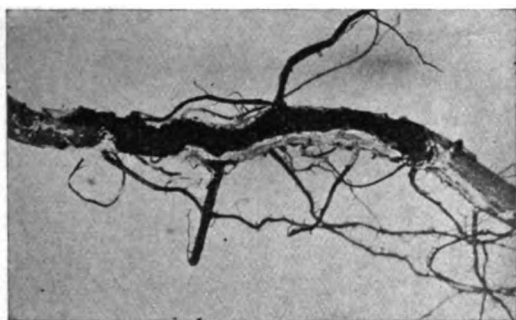


Fig. 60.

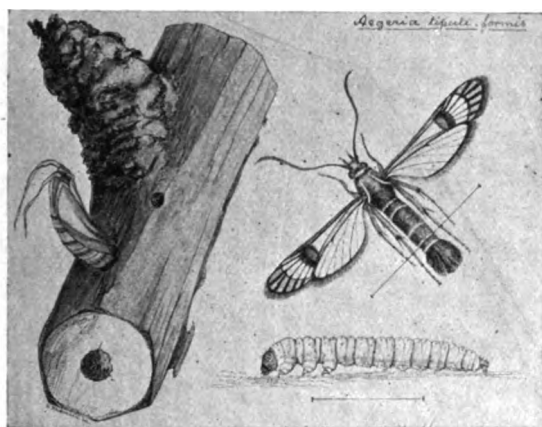


FIG. 62.

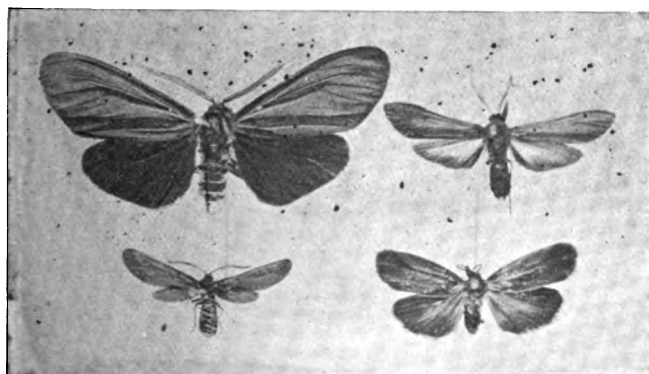


FIG. 72,'b.

FIG. 72, d

Fig. 60.—Roots of plum tree infested with borers.

Fig. 62.—*Sesia tipuliformis* Linn.

Fig. 72, a, *Harrisima americana* Harr.; b, *Scepis fulvicollis* Hbn.; c, *Ctenucha virginica* Charp.; d, *Hypoprepia fucosa* Hbn.

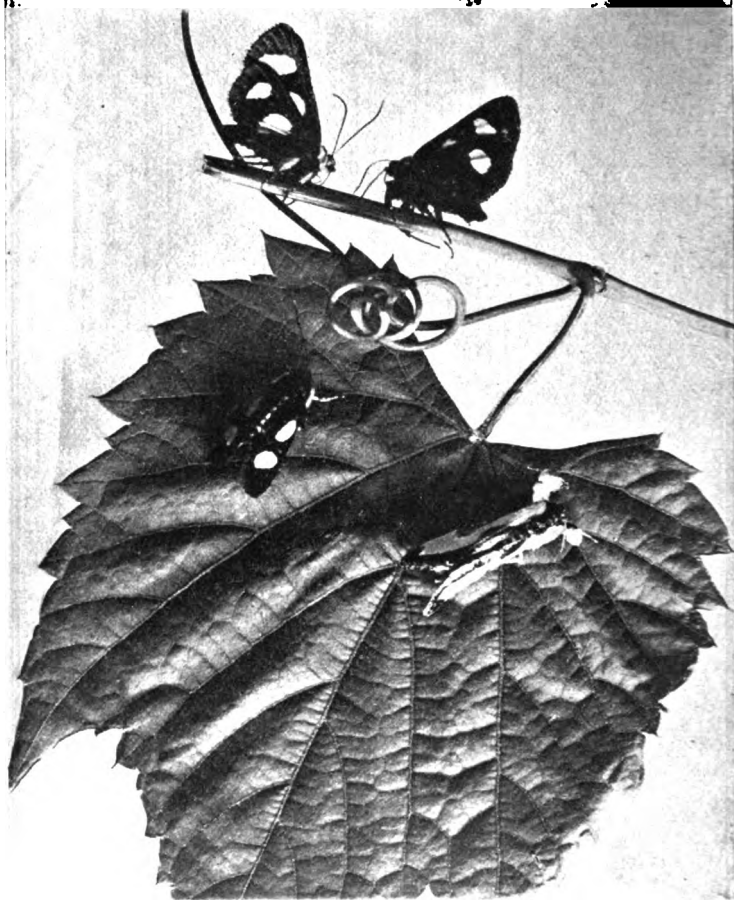
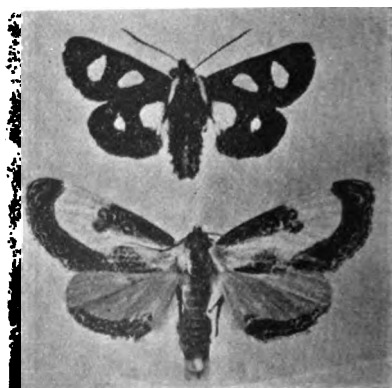
FIG.
65.FIG.
70, d.FIG.
70, b.

Fig. 65.—*Alypia 8-maculata* Hbn., three moths; and *Eudryas grata* Fab., one moth.
Fig. 70, a, *Alypia 8-maculata* Hbn.; b, *Psychomorpha epimenis* Dru.; c, *Eudryas grata* Fab.; d, *Eudryas unio* Fab.

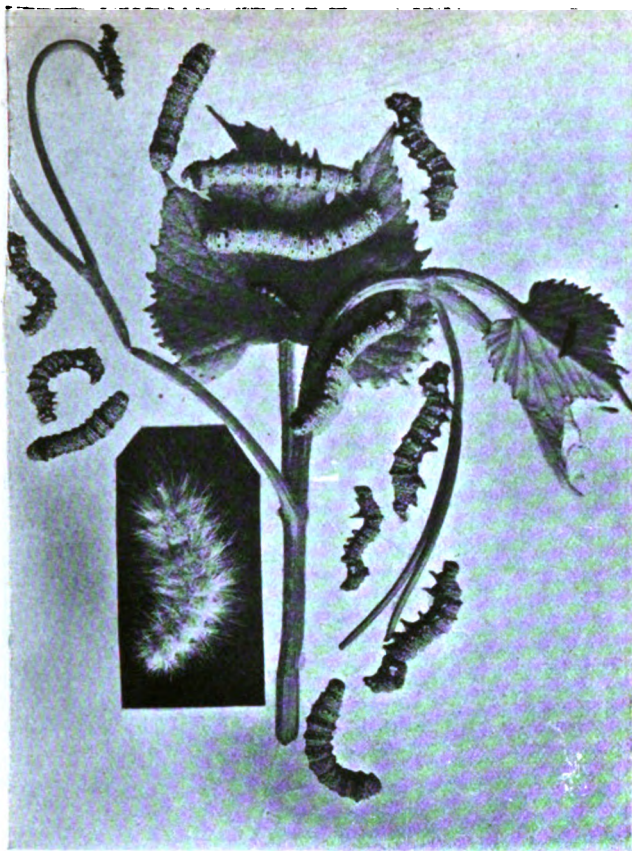


FIG. 76.

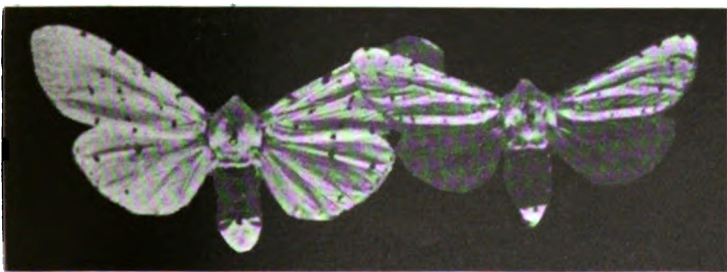


Fig. 64.—*Alypia octomaculata* Hbn., caterpillars, and one parasitized larva of *Spilosoma virginica* Fab.

Fig. 76.—*Pyrrharctia isabella* S. & A.

Fig. 77.—*Leucarctia acraea* Dru., male and female.

FIG.
68.

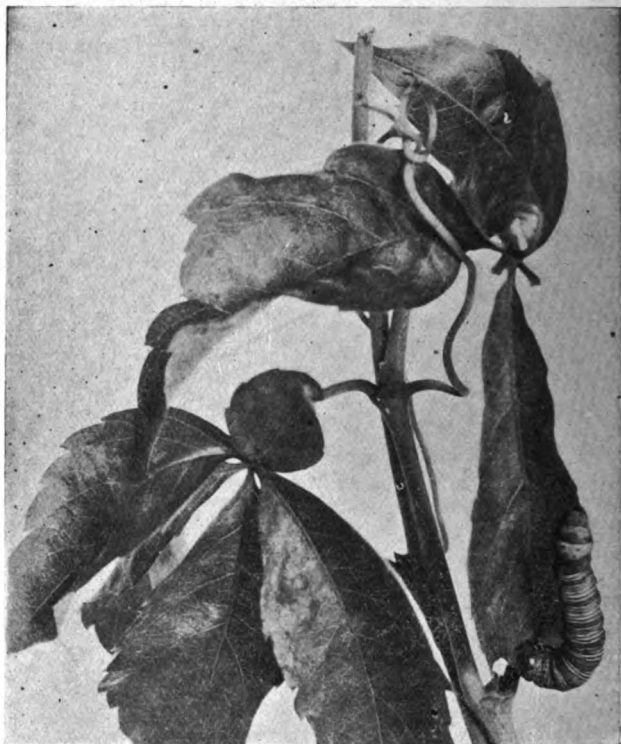


FIG.
74, a.

FIG.
74, b.

FIG.
74, c.

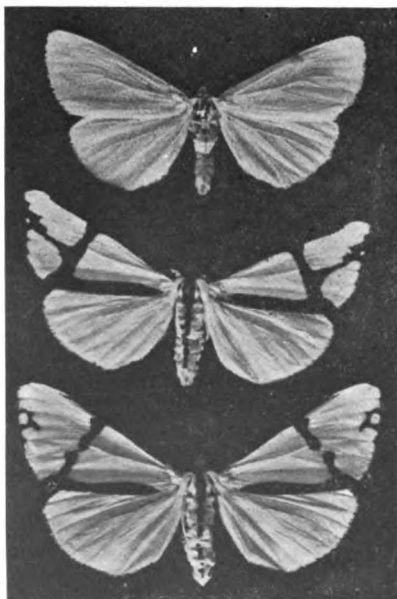


FIG. 105.

Fig. 68 — *Eudryas grata* Fab., caterpillar.
Fig. 74. — a, *Callimorpha tulvicosta*; b and c, *Contigna* Walk.
Fig. 105. — *Datana ministra*, male and female.

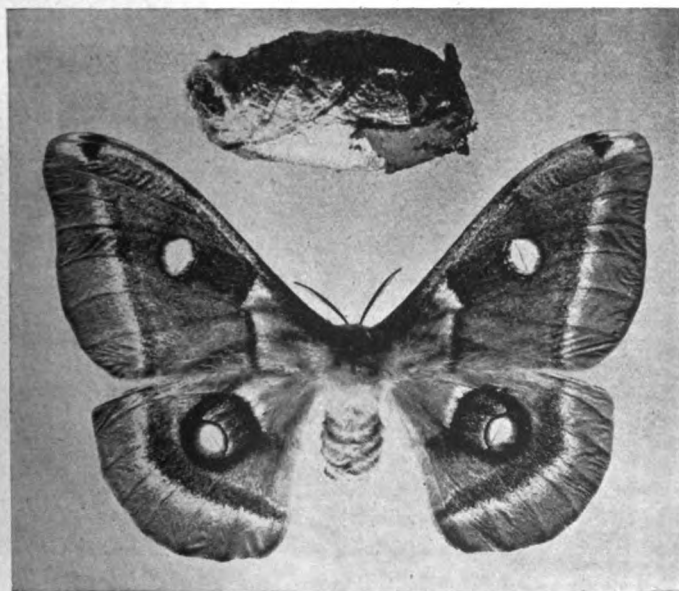
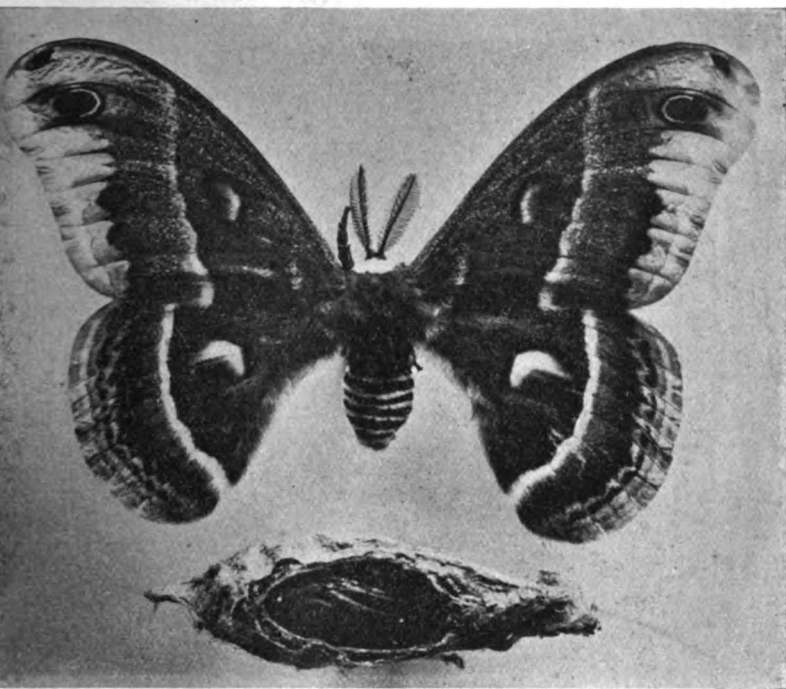


Fig. 123.—*Attacus cecropia* Linn., reduced in size.
Fig. 126.—*Telea polyphemus* Linn., reduced in size.

FIG. 124



FIG. 110.



FIG. 199.



Fig. 124.—Parasitized caterpillars of *Attacus cecropia* Linn.
 Fig. 110.—*Edemasia concinna*, S. & A., caterpillar.
 Fig. 199.—*Petrophora diversilineata* Hub., moth at rest.



FIG. 128.

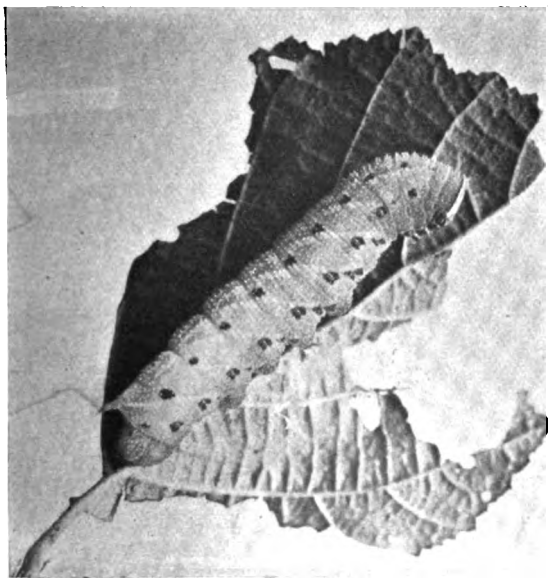


FIG. 55.

Fig. 128.—*Actias luna* Linn., reduced.
Fig. 55.—*Smerinthus geminatus* Say., caterpillar.

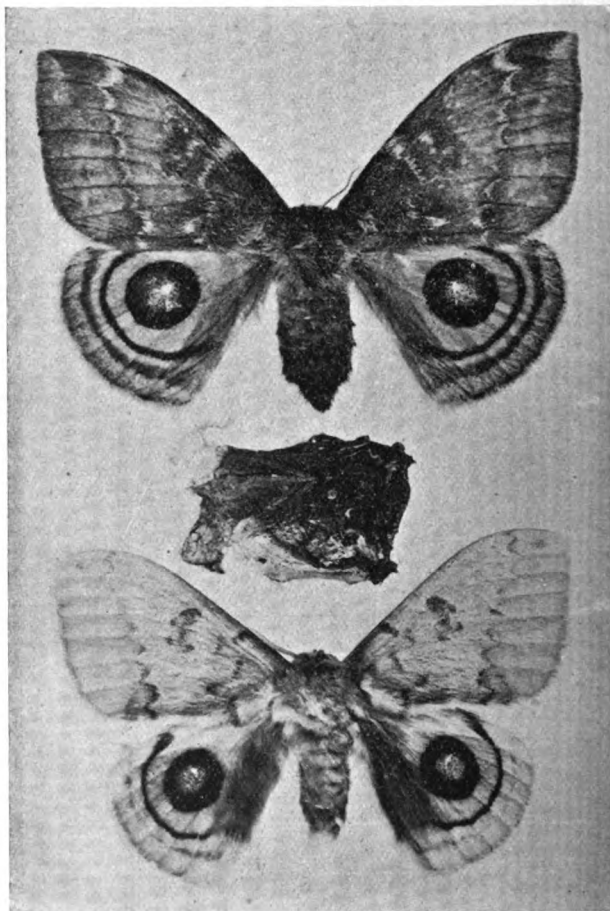


FIG.
129.



FIG. 151.



Fig. 129.—*Hyperchiria Io* Linn., male and female.
Fig. 151.—*Thyatira scripta* Gosse.
Fig. 187.—*Caterva catenaria* Cram., and pupa in cocoon.

PLATE XVII.

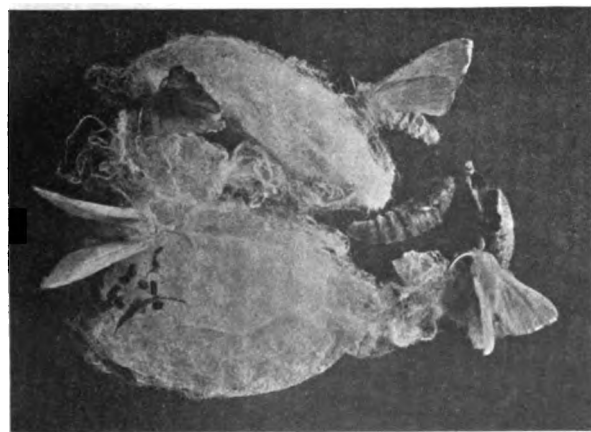
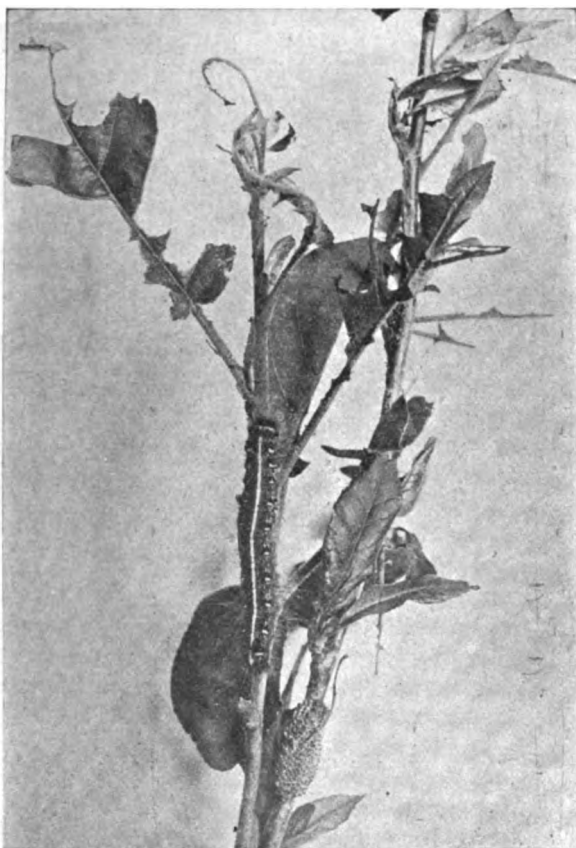


Fig. 137.—Caterpillar of *Clisiocampa americana* Harr.
Fig. 140.—Moths, pupa and cocoons of *Clisiocampa distria* Hub.

FIG. 138.



FIG. 181.

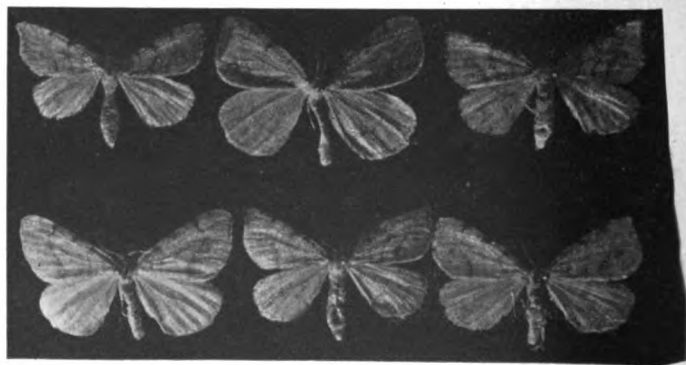


Fig. 138.—*Clisiocampa americana* Harr., tent.
Fig. 181.—Six forms of *Diastictis flavicaria* Pack.

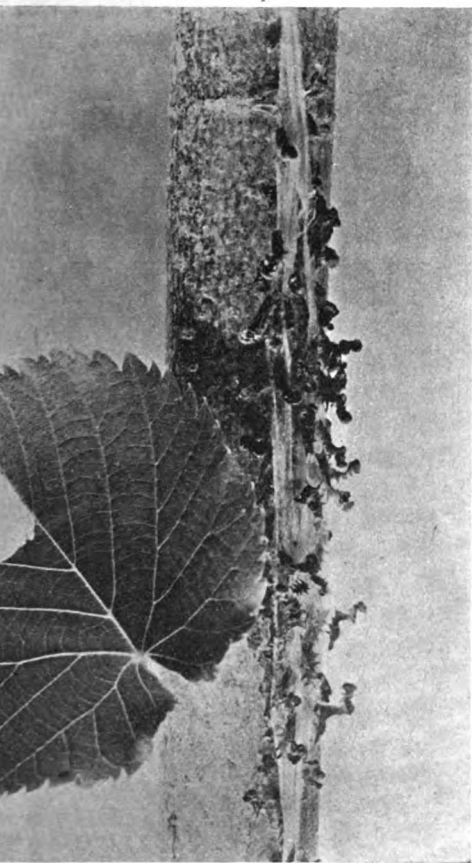


FIG. 142.



FIG. 141.



FIG. 114.



FIG. 115.



FIG. 113.



FIG. 121.

11.—*Clisiocampa distria* Hub., larvæ crowding together; greatly reduced.
 12.—*Clisiocampa distria* Hub., empty skins of young caterpillars; natural size.
 14.—*Schizura ipomeæ* Doubl. Fig. 115.—*Schizura ipomeæ* Doubl., larva.
 13.—*Schizura unicornis* S. & A. Fig. 121.—*Cerura borealis* Bdv.

FIG. 143.

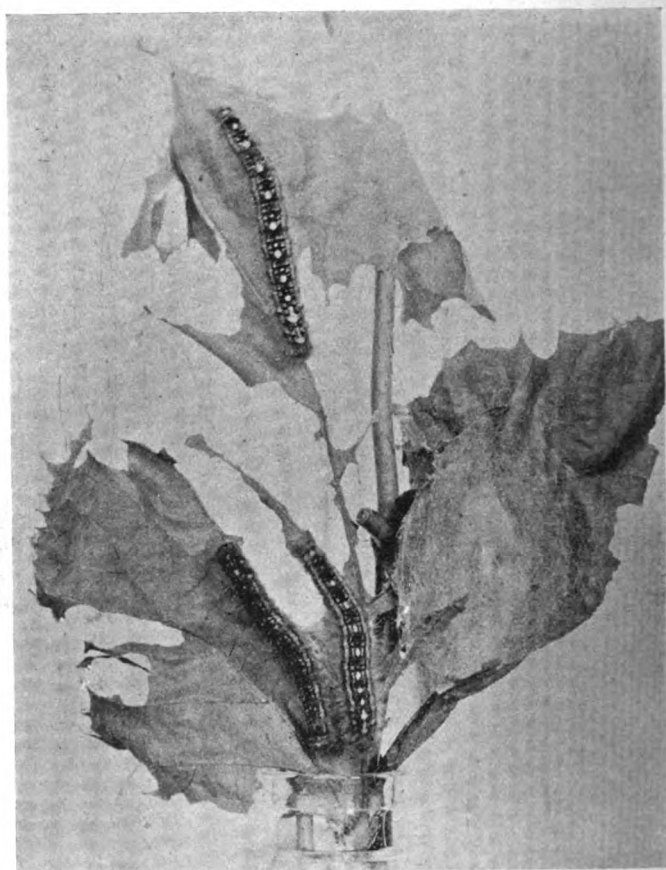


FIG. 95.

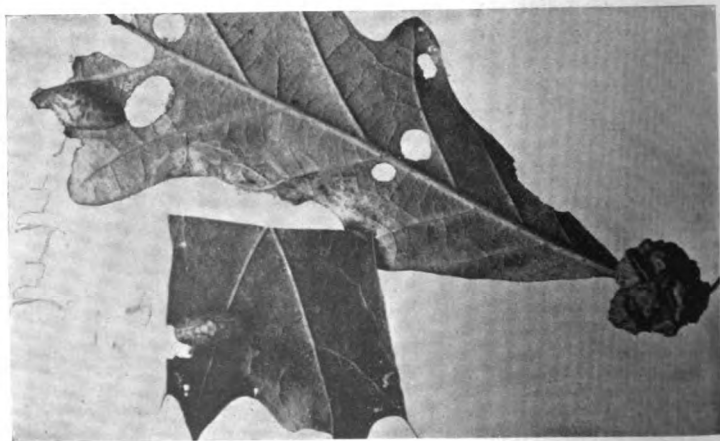


Fig. 143.—*Clisiocampa distria* Hub., caterpillars.
Fig. 95.—Slug caterpillars on oak leaf.



FIG. 87.



FIG. 88.



FIG. 90.

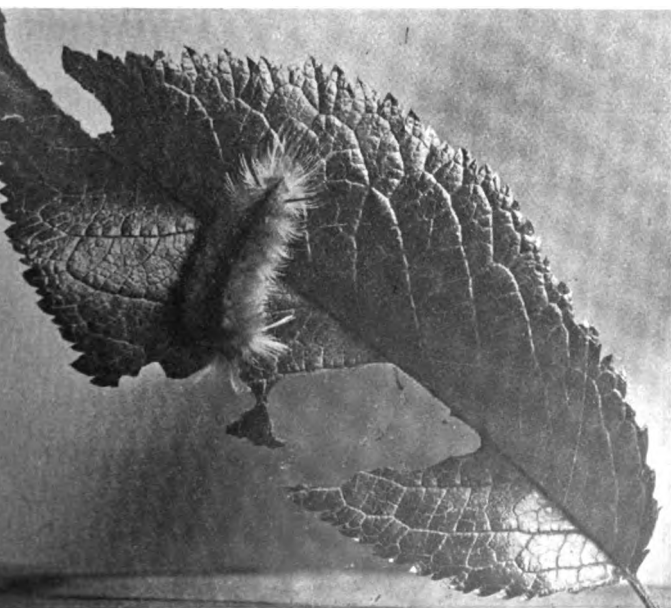


Fig. 83.—*Halesidota tessellata* S. & A., caterpillar.

Fig. 84.—*Halesidota carya* Harr.

Fig. 85.—*Halesidota maculata* Harr.

Fig. 86.—*Halesidota tessellata* S. & A.

Fig. 87.—*Orgyia leucostigma* S. & A.

Fig. 88.—*Parorgyia parallela* G. & R.

Fig. 90.—*Lagoa crispata* Pack.

FIG. 79.



FIG. 92.



FIG. 94.



FIG. 96.



Fig. 79.—*Hyphantria cunea* Drury, tent.
Fig. 92.—*Parasa chloris* H. Sch., caterpillar.

Fig. 94.—*Euclea penulata* Clem.
Fig. 96.—*Adoneta spinuloides* H. S.

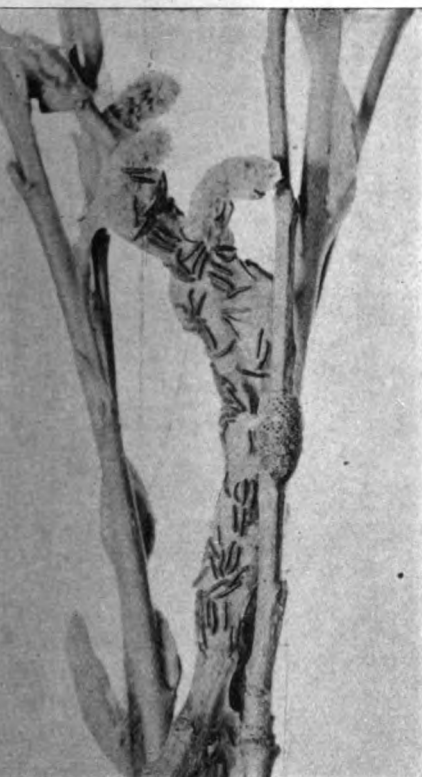


FIG 144.



FIG. 170½.



FIG. 173.



FIG. 160.



FIG.
170.

Fig. 144.—Tent caterpillars just hatched; also egg mass.
 Fig. 166.—Larvæ of *Gortyna nitela* Gu., in stems of currant and grape vine.
 Fig. 170½.—*Scopelosoma sidus* Gu.
 Fig. 173.—*Xylina Bethunei* G. & R.
 Fig. 160.—*Carneades scandens* Ril.

FIG.
177.

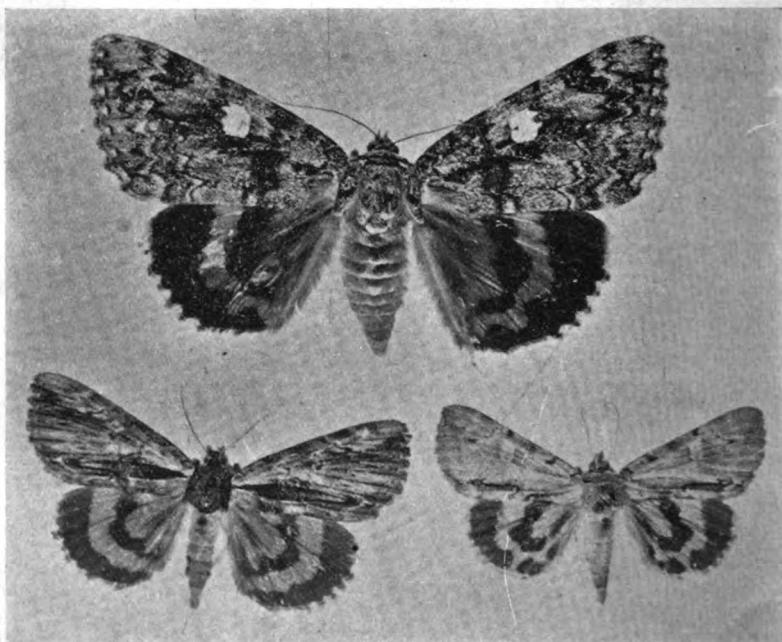


FIG.
175.

FIG.
176.

FIG.
147.

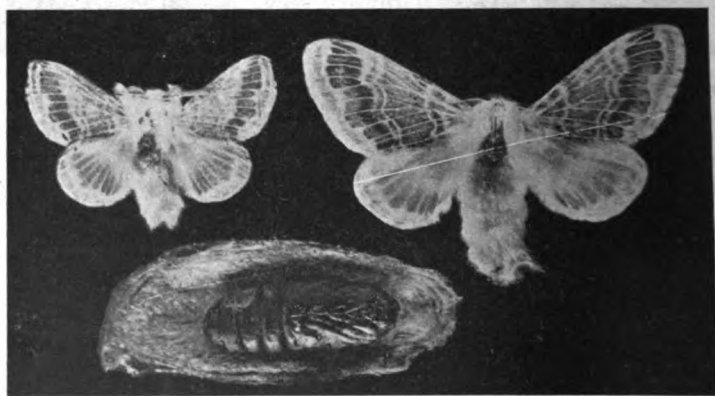


FIG.
149.



Fig. 147.—*Tolyte vellea* Stoll., and open cocoon.
Fig. 149.—*Gastropacha americana* Harr.

Fig. 176.—*Catocala grynea* Cram.
Fig. 177.—*Catocala polycogama* Gu.

Fig. 175.—*Catocala ultronia* Hub.

4
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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN NO. 62.

DIVISION OF AGRICULTURE.



Fig. 288. Originating varieties of wheat.

MARCH, 1899.

WHEAT.

VARIETIES, BREEDING, CULTIVATION.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

McGILL-WARNER CO., PRINTERS, ST. PAUL.

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The bulletins of this station are mailed free to all residents of the state who make application for them.

WHEAT.

VARIETIES, BREEDING, CULTIVATION.

WILLET M. HAYS AND ANDREW BOSS.

Minnesota's large annual wheat sales; the superior quality of wheat grown in the Northwest, early designated "No. 1 hard;" the wonderful flour milling industry which has developed the state; the business of wheat and flour transportation; and the growing of this cereal,—place this crop among our largest interests. Dairying and general stock farming should and will gradually replace special wheat farming. But since the rotation and fertilizing of the fields which come with the keeping of domestic animals provides the best soil conditions for wheat, that crop is destined to continue as an important factor on most of our farms, and our wheat interest will doubtless increase rather than decline. The yields of wheat under continuous wheat cropping, when the rich character of our soils is considered, are ridiculously low. The experiment station has under way extensive experiments in rotating, pasturing, manuring, and cultivating fields to learn how best to prepare them for crops of grain. Many of these tests have already been under way for five years. While most of these experiments are not yet completed, but will be reported in later bulletins, results already reached warrant the statement that the average yields per acre of wheat can be increased 25 to 50 per cent. by so rotating the crops and manuring and cultivating the fields best to prepare the soil for this crop.

Next in importance to preparing the field for the crop of wheat is the choice of those varieties and strains which will yield the

greatest value per acre to the farmer, and will best uphold and improve the value of the flour made by our mills, and will best serve as human food. This bulletin is devoted mainly to the work of securing better varieties; the testing of varieties in the field and in the mill, in the bake-room and in the laboratory; and the improvement of wheats by breeding. Plant breeding is in its infancy, and plans for extensively and scientifically breeding this crop had to be devised rather than copied. It is believed that varieties materially improved in yield are evidence that the plans in use are so designed that increased yields of wheat will result from the new wheats being evolved and disseminated in the various counties throughout the state. The evidence certainly is good that better farming will add several bushels per acre to our yields of wheat, and that improved varieties will add in addition at least several pecks per acre.

COLLECTING AND TESTING VARIETIES OF WHEAT

In 1888, the first year after the Minnesota Experiment Station was established, efforts were begun to find the varieties of wheat best adapted to this state. The chief points in mind were to secure kinds of wheat which would yield the largest profits per acre for the farmer, would supply our flour mills with wheat of superior quality, and would be the most nourishing and valuable as human food.

In 1888 and 1889 D. N. Harper and W. M. Hays collected from various sources about 200 varieties, or samples, of wheat. The best wheats grown in Minnesota were secured, and numerous varieties were obtained from other states. A large number were also secured through American consuls in Russia, Hungary and other European countries, experiment stations, grain merchants, and persons in Canada. Most of the varieties were spring wheats.

Chemical analyses were made of many of these samples by Prof. D. N. Harper, then station chemist, "to determine whether any o

varieties were superior to our own." These analyses showed Hungarian and many of the Russian wheats to be of great value, but none were more valuable than our Fife and Blue Stem. Through the courtesy of Senator S. A. March, of Minneapolis, a large number of these wheats were planted on the "March Farm," in 1890, at Warren, in the Red River Valley, near the northwestern corner of the state. The small plots available of most samples necessitated the use of plots so small that it was impracticable to make tests or even close estimates of the yields of the different wheats, though the planting and harvesting were carefully done, and notes were taken on each kind of wheat. Some proved to be winter wheats. A large number died or produced inferior plants, or grain of such poor quality that they were once discarded. The general results proved that our own varieties are superior to any of the foreign ones. Some of the Russian seeds yielded grain of apparently as good quality as our own, and these varieties were tested further. The Russian samples consisted mostly of mixed varieties of bearded and beardless wheats. A sufficient seed was secured of 75 of the better varieties that a one-acre plot of each was planted in 1891 in the southeastern part of the Red River Valley, at Glyndon. These wheats proved to be mostly of the Fife type from Minnesota and Russian samples. At Glyndon, fair yields of grain of good quality were obtained of most of these wheats. The yields, however, were not fully complete, and have not since been used in the summaries of comparative yields. In 1892 part of these wheats were grown at University Farm, St. Anthony Park, but the crop was so unsatisfactory that the yields were not recorded. In 1892 and 1893 a total of 110 varieties of wheat were grown at Fargo, N. D., the larger number of which were those originally collected by the Minnesota station. The destruction by fire of the Minnesota station office building in the fall of 1890, the correspondence relating to these varieties of wheat and the laboratory book containing their source, names, characteristics and other facts concerning them, were burned. The marking each variety bore only the laboratory serial number, together with the numbers of the respective plots, and thus

a lot of wheats without names or records of source, kind or quality were in hand. While this was a serious misfortune, it led to the more careful inquiry into the real merits of each variety. In 1891, records of each variety were kept by using the name of the town, Glyndon, and our original laboratory entry number, e. g., Glyndon 811, and these numbers finally became our names for these wheats.

During the years 1892 to 1898, inclusive, various other varieties were collected from the states and countries above mentioned. Many new varieties were also secured from New South Wales, Australia, and a large number were originated at this station by selection, and also by crossing and selection. The total number of wheats having been under trial up to the present time is 552. Many of the collected wheats were discarded after a single trial in the crop garden. Not in all cases have the seasons and the soils been such as to give yields which it has seemed wise to use in tabulating and summarizing. Discarding the results of such years and places as gave yields which were not fairly comparable, we yet have about a dozen which can fairly be averaged for comparison.

The expense of all these trials has been large. It was not foreseen that so many trials, covering such a long period of years, and such a variety of soils, localities and climatic conditions, would be necessary. Looking backward, it can be seen that simple milling tests would have assisted early in the trials in throwing out some varieties of average yield, and of a quality too poor to be desirable. But on the whole this patient deliberation seems to have been the only safe method.

The immense financial considerations at stake certainly warranted that sufficient care and expense be incurred to enable the state to know which are its best varieties of wheat, and to find and distribute them to the farmers of the state.

WHERE THE TESTS FOR YIELD WERE MADE.

At the North Dakota Experiment Station most satisfactory comparisons were made of these varieties in 1892 and 1893.

A sufficient number of trials had then been made to warrant comparison and many of those yielding poorly, and those of poor

ty were discarded. In 1895, 1896, 1897 and 1898 these
ts were planted at University Farm and at North Dakota
eriment Station, and from year to year the poorer varieties
discarded at each station. In 1897 and 1898 the best vari-
remaining were also grown at Northwest Experiment Farm,
kston, Minn., and at Northeast Experiment Farm, Grand
ds, Minn. The trials at these stations will be specially report-
on in another bulletin. In 1898 the South Dakota and Iowa
ns also grew a few of the best varieties.

METHOD OF MAKING THE FIELD TESTS.

e methods used in testing the varieties have been improved



Fig. 239. Plowing for Variety Tests of Wheat.

from year to year. Originally it cost about three dollars per
to plant, harvest and thresh carefully each plot containing 1-20
10 of an acre. With the addition of specially chosen seeding
harvesting machinery, with specially constructed threshing
ines and other handy arrangements, including a portable gas-
e threshing engine at University Farm, the cost has been re-

duced to one-half the former amount. An important factor in successfully carrying on these field trials has been the excellent character and the loyal interest of the workmen and students who have performed the manual labor.

THE PREPARATION OF THE LAND.

The land of the Minnesota experiment farms is platted into series eight rods wide and as long as the field is wide, usually about forty rods. The plots run across the series, and are one or two rods wide, and contain 1-20 or 1-10 of an acre. The rotation of crops for a few years previous is so managed as to prepare the land for the wheat. Light applications of rotted barnyard manure are made to some crops, as corn, roots or millet, one or two years previous to using the land for tests of small grains, but no concentrated fertilizers are used. The frequency of the manuring is determined by the needs of the land. The manure is not applied so frequently that when wheat is grown in a moist year it will lodge badly. The land is kept in that state of fertility which is practicable on all our better farms.

In preparing for variety tests of wheat, grass land is fall-plowed, or if following a cultivated crop, as corn or potatoes, the seed bed is made mellow by means of the disk harrow. The common drag or "Tower's Pulverizer" is used in making the surface fine and even.

THE SOIL.

The soil and subsoil at University Farm are medium in texture with clay and sand mixed in such proportion that rainfall is absorbed rather freely and to a good depth, and is conserved quite well in seasons of drouth. At a depth of five to six feet the subsoil is gravel and sand, giving excellent underdrainage, but in times of drouth making the land less able to supply water to crops than if there were clay or mixed subsoil to a greater depth.

The soils used in the Red River Valley, at Glyndon, Euclid, Fargo and Crookston are the rich, peculiar clay soils characteristic of this noted wheat region. The soil used at Northeast Farm is a sandy loam, new, and sufficiently full of available fertility and

ture to produce fair crops of wheat. At these farms the soils are far more uniform than at many experiment stations where the unevenness of the land makes variety testing very unsatisfactory and even impracticable.

THE METHOD OF PLANTING.

Sufficient thoroughly cleaned seed of each variety is weighed to plant somewhat more than the respective plots. A shoe $8\frac{1}{4}$ ft. wide is used, thus sowing a rod in width each time the machine passes twice over the plot. See Fig. 240. When the plot is made the seeds remaining in the cups in the bottom of the drill are removed as cleanly as may be with the hands. The operator then blows out, by means of a rubber tube, every remaining seed. It is necessary to have sufficient seed in the drill box to prevent the re-feeding device from running so nearly empty that it will drop seeds thinly on the latter portion of the plot. An alley two rods wide is left between each two plots of grain. This places the varieties only two feet apart, but as wheat is nearly always cross-pollinized,—the pistil of a given flower being pollenized from anthers of the same flower,—there is but little cross breeding of varieties. The weeds are hoed out of these alleys a few times in the summer growing season.

CARE OF GRAIN FROM SEED-TIME TO HARVEST.

Nothing is done with these plots before they ripen unless some occasional rank-growing or dangerous weeds need removing. In the case of a newly secured variety the plot is gone over between the time the grain is headed and before it is fully ripened, and all plants of that variety are removed. Many of the Russian wheats, many of the earlier and of recent importations, are very badly mixed. These wheats are the best samples of the commercial wheats of the foreign markets. Many of them were made up of three to four kinds of wheat, distinct as to color of chaff, length of awns, color and form of berry, etc. In some cases no one wheat has been in the majority, and a small plot has been utilized from which to select one or more prominent types for further trial.

Method of Harvesting Variety Test Plots.—Where the relative

earliness of the varieties has been learned by previous trials in the garden or field tests, the varieties are planted in order of earliness. This allows the self-binder to be started at one end of the series, and each plot is cut as it ripens. The cutting is all done in one direction. One or two men assist the driver and carefully clean the machine upon finishing each plot. They also carefully gather the bundles and any loose grain of each plot into shocks, beside which they place the labeled stake of the plot.

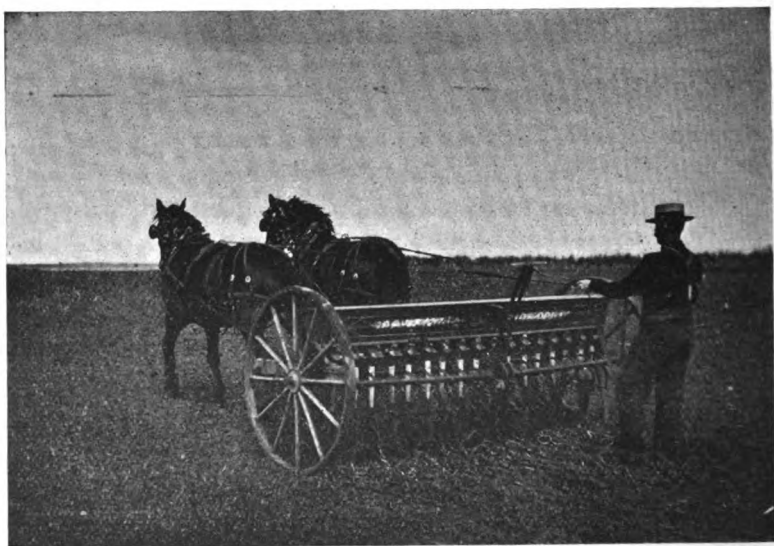


Fig. 240. Seeding the Variety Plots with Shod-chain Drill.

The Method of Threshing Varieties of Wheat.—As soon as the grain has become well dried in the shock it is threshed. Much care is given to cleaning wagon racks between each load, handling the bundles at the threshing machine and caring for the threshed grain to prevent the mixture of the different varieties.

A Victory separator, which cleans itself so thoroughly that stopping between plots to sweep out the machine has not been necessary, was secured from the Minneapolis Threshing Machine Co. See Fig. 242. This make of machine was selected as being the

siest of the numerous kinds examined to make over into a separator for this sort of work. The firm cheerfully made changes suggested, so that the machine would shake out clean by running two or three minutes after the last bundle was fed into the cylinder. After stopping the feeding of bundles, a pail is held under the discharge spout of the elevator which brings the tailings back to the cylinder, thus stopping the feeding of all grain into the machine that it may be shaken out clean.

A Trial of the Threshing Machine in Doing Clean Work.—In 1897 several beardless varieties known to be without admixture of bearded wheats were threshed, each one immediately after a bearded variety had been run through the machine. In 1898 these beardless varieties were sown, and notes were made at harvest time of the percentage of bearded heads showing in each. There were practically no bearded heads in any of the three plots of beardless wheats, thus proving that this threshing machine, when properly managed, separates the varieties perfectly.

Note:—Numbers Used for Names. The loss of the names of many of the varieties, some of which were similar to one another in appearance, led us to the adoption of numbers for all names. We were further led to this course by the fact that new varieties were constantly originating, many of which were in appearance exactly counterparts of the varieties from which they had sprung. We therefore adopted in lieu of all names the words "Minnesota Number" and our Variety History Book number, commonly abbreviated and written "Minn. No. 149," "Minn. No. 66," etc. This plan contemplates using names of wheats only as names of classes or types. It is impossible to give a description of some of our new best yielding wheats by which farmers or even experts can identify them. Some differ only in their ability to yield better, others only in the superiority of their flour. These characters of intrinsic value are the qualities we are seeking. The profits of wheat raising do not depend upon the distinguishing botanical characters of the wheat. If our wheat crop can be increased one bushel per acre by seeking only for field crop and quality of flour, all names and peculiar botanical descriptions will appear relatively as exceedingly small factors. Systematists in botany, and bird book promoters in animal breeding, divert the attention of breeders too much from intrinsic quality to mere distinguishing marks. This system of naming with mere numbers has been used for several years with most satisfactory results. With such a system of names the effort is directed more to actually knowing that the seed came from the original stock which gained a reputation for superior merit producing wealth, and it is believed there will be less temptation for dealers to substitute stocks and sell them under a popular name. This is especially true of varieties which have a published record of superior merit. The record and the number name must go together to represent value. Formerly we used the word "University" with the number of the variety, abbreviated thus: "Univ. No. 149." Hereafter we shall use the word Minnesota with the number, thus: "Minn. No. 149," "Minn. No. 169," etc. While the abbreviation "Univ. No." has been somewhat used in our publications, it has been extensively used in connection with only one variety of field crop which has been distributed from this station, viz.: Univ. No. 1 corn. Since this corn with further improvement, from longer selection, will ere long be sent out under a new number, no serious inconvenience will come from the change.

With the need for breeding field crops emphasized, and its importance more fully demonstrated, this matter of names will become an important subject.

SAVING, TESTING AND TREATING SEED WHEAT IN VARIETY TESTS.

To be doubly safe in threshing the varieties of wheat, the work proceeds as follows: As the grain from each plot comes from the machine the first half bushel or so is put into a large sack. Then a half bushel of grain is caught and saved in a small sack for planting the next year, thus avoiding the use for seed of that portion which comes from the separator immediately after the grain of the preceding plot, which might contain kernels of that variety. The balance of the grain is then put into the large sack with that which first came through the machine. See Fig. 243. Constant care is used that the interior of the machine is always in good repair and that there are no places where the grain can lodge. Care is taken at all points to keep the seed grain dry and strong in germinating power, that all varieties in the variety tests may have an equal number of plants per acre on the start.

That sufficient seed of each variety may be planted to insure a full stand, it is necessary to know the vitality of the seeds of each kind. This is of special importance when rains prior to threshing or slight dampness at the time of storing the grain have resulted in injury to the seeds. A germinating chamber adapted to testing seed wheat at the low temperatures prevailing in the soil at the season of sowing spring wheat is used for testing the vitality of wheats and other seeds. See Fig. 245.

Where necessary to treat the seed grain for smut, the blue stone, the formaldehyde, the corrosive sublimate, the hot water, or other suitable method, is used.

PROGRESS AND RESULTS OF TRIALS OF COLLECTED WHEATS.

Ending with Dec. 31, 1898, 552 varieties or samples of wheat have been entered in the Variety History Book of the Minnesota Experiment Station. The larger part of these samples came from foreign countries and states, a number from Minnesota farmers, and 49 varieties have been originated, 6 of which are cross bred wheats.

Prior to 1894 about 200 varieties of wheats had been collected by the Minnesota and North Dakota stations, and these have since been under co-operative experimentation. Only a portion of the

Yields secured under the varying conditions can here be recorded, and only a portion of the data can be given room. Some of these data collected prior to 1897 may be found in bulletins 15, 31, 40,



Fig. 241. Weighing the Bundles from a $\frac{1}{20}$ Acre Plot.

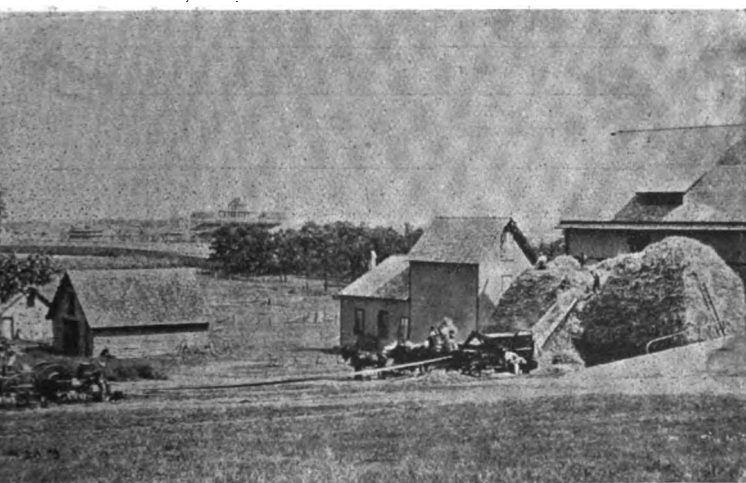


Fig. 242. Threshing the Variety Plots.

TABLE XXI.—Wheat, Yields for all Years and all Farms.

VARIETY.	Minnesota Number.	Fargo, 1892.	Fargo, 1893.	Fargo, 1894.	Coteau, 1894.	Bucild, 1894.	University F., 1894.	Coteau, 1895.	University F., 1895.	Fargo, 1896.	University F., 1896.	University F., 1897.	University F., 1898.	Northwest F., 1898.	Northeast F., 1898.	South Dakota, 1898.	North Dakota, 1898.	Iowa, 1898.
Blount's Hybrid No. 15.....	13	17.3	12.8	6.3	23.8	.....	.....	23.5	29.0	17.0	21.2	15.5	.....	.....	.....	.....	27.5	.....
White Russian.....	19	17.7	11.9	.....	23.0	.....	.....	21.5	33.2	19.7	24.8	16.3	.....	.....	.....	.....	30.0	.....
Haynes' Blue Stem.....	51	16.7	12.9	15.0	.....	.....	.....	24.7	21.6	23.4	24.6	20.4	23.3	.....	23.0	20.2	33.5	8.8
Power's Fife.....	66	21.3	15.1	12.6	19.8	15.8	.....	22.8	26.3	22.5	21.4	17.4	24.0	18.8	20.7	17.4	32.0	7.0
Rio Grande.....	72	14.7	13.4	.....	13.6	13.5	.....	20.7	29.3	18.0	20.2	15.2	.....	.....	.....	.....	30.8	.....
Glyndon 711.....	105	23.3	10.0	9.7	21.4	16.0	.....	22.8	31.8	18.2	21.4	17.8	22.3	18.3	14.7	.....	32.0	.....
Glyndon 753.....	116	14.7	14.3	15.3	19.3	17.2	.....	20.6	31.5	17.0	21.0	19.7	.....	.....	.....	.....	33.1	.....
Bolton's Blue Stem.....	146	.....	17.8	12.3	21.4	15.3	.....	20.0	35.3	23.2	25.1	21.5	22.5	.....	19.3	17.3	35.3	6.3
Power's Fife.....	149	.....	.....	.....	.....	.....	11.4	36.2	22.7	23.3	19.9	26.5	22.3	14.0	15.4	33.8	7.5	.....

Glyndon 818.....	155	.....	.....	.....	.....	14.4	.....	32.8	22.7	23.3	20.8	26.8	23.5	14.7	.....	35.2	6.8
Glyndon 753.....	157	.....	.....	.....	.....	18.3	.....	30.9	27.5	22.0	21.4	26.6	20.2	16.2	.....	36.5	7.0
Haynes' Blue Stem.....	161	.....	.....	.....	.....	15.0	.....	27.2	.....	25.0	18.9	18.2	19.6	.....	.....	.....	.....
Glyndon 811.....	163	.....	.....	.....	.....	33.0	.....	42.7	.....	23.0	19.9	25.0	20.3	14.7	15.4	37.2	8.0
Glyndon 761.....	167	.....	.....	.....	.....	11.7	.....	35.0	.....	24.9	19.7	27.0	26.2	15.7	.....	34.7	.....
*Haynes' Blue Stem.....	169	.....	.....	.....	.....	15.4	.....	37.8	.....	25.0	24.3	26.3	22.5	19.3	14.1	38.4	12.5
*Rising's Pife.....	171	.....	.....	.....	.....	26.2	.....	35.4	.....	21.7	19.8	26.3	24.5	16.7	16.7	38.1	8.6
Weilman's Pife.....	172	.....	.....	.....	.....	11.3	.....	33.3	.....	22.2	19.5	.....	26.8	.....	.....	.....	.....
*McKendry's Pife.....	180	.....	.....	.....	.....	14.2	.....	34.5	.....	.....	19.5	26.5	21.5	17.3	13.3	35.5	.....
Lost Nation.....	183	.....	.....	.....	.....	.....	.....	32.8	.....	.....	16.8	24.0	.....	.....	.....	.....	.....
North Star.....	184	.....	.....	.....	.....	.....	.....	30.0	.....	.....	14.1	22.2	.....	.....	.....	.....	.....
Advance.....	185	.....	.....	.....	.....	.....	.....	45.4	.....	18.7	18.3	23.0	16.0	16.5	13.8	33.0	9.6
Crown.....	186	.....	.....	.....	.....	.....	.....	36.2	.....	18.7	18.8	18.0	.....	.....	.....	.....	.....

TABLE XXI.—Wheat, Yields for all Years and all Farms—Continued.

VARIETY.	Minnesota Number.	Farco, 1892	Farco, 1893	Farco, 1894	Coteau, 1894	Bucld, 1894	University F., 1894	Coteau, 1895	University F., 1895	Farco, 1896	University F., 1896	University F., 1897	University F., 1898	Northwest F., 1898	Northeast F., 1898	South Dakota, 1898	North Dakota, 1898	Iowa, 1898
Stanley.....	187	.....	.....	.....	.....	.....	.....	.....	57.5	.....	18.0	12.7	14.3	.....	.....	.....	.....	.....
Preston.....	188	.....	.....	.....	.....	.....	.....	.....	44.0	.....	27.0	20.6	26.3	19.3	15.2	17.2	36.5	9.6
Percy.....	189	.....	.....	.....	.....	.....	.....	.....	29.7	.....	19.7	12.9	.....	.....	.....	.....	.....	.....
No. 1 Nicopol Circa.....	195	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	17.6	14.2	.....	.....	.....	.....	.....
No. 3 Nicopol Circa.....	196	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15.4	9.7	.....	.....	.....	.....	.....
No. 4 Kocharka.....	197											19.8	18.3					
No. 6 Odessa.....	198											19.8	17.3					
No. 6 Odessa.....	199											15.4	23.2					
No. 2 Nicopol Circa.....	200											19.8						

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TABLE XXI.—Wheat, Yields for all Years and all Farms.—Concluded.

VARIETIES.	Minnesota Number.	Fargo, 1892.	Fargo, 1893.	Fargo, 1894.	Coteau, 1894.	Euclid, 1894.	University F., 1894.	Coteau, 1895.	University F., 1895.	Fargo, 1896.	University F., 1896.	University F., 1897.	University F., 1898.	Northwest F., 1898.	Northeast F., 1898.	South Dakota, 1898.	North Dakota, 1898.	Iowa, 1898.
Haynes' Blue Stem X.....	289	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.0	20.4	26.0	17.6	.....	.....	.....	.....
Glyndon 761.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haynes' Blue Stem X.....	290	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.3	15.5	27.6	16.8	.....	.....	.....	.....
Glyndon 811.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haynes' Blue Stem X.....	291	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.3	19.3	27.0	20.0	.....	.....	.....	.....
Glyndon 811.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rising's Fife X.....	292	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.0	17.9	32.0	17.7	.....	.....	.....	.....
Rising's Fife.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rising's Fife X.....	293	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.2	18.0	21.3	20.0	.....	.....	.....	.....
Rising's Fife.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Haynes' Blue Stem.....	294	.....	.....	.....	.....	.....	.....	.....	.....	.....	25.3	21.3	24.8	26.5	.....	.....	.....	.....
Improved Blue Stem.....	295	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.3	22.0	26.6	27.8	.....	.....	.....	.....
Countess.....	451	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.7	11.0	.....	.....	.....	.....	.....	.....
Ladoga.....	452	.....	.....	.....	.....	.....	.....	.....	.....	.....	19.2	12.0	.....	.....	.....	.....	.....	.....
Perry.....	453	.....	.....	.....	.....	.....	.....	.....	.....	.....	18.3	13.3	.....	.....	.....	.....	.....	.....

46 and 50, and in the annual reports of this station for 1893, 1894, 1895 and 1896; and in bulletins 10, 11, 23 and 37 of North Dakota Experiment Station.

In 1897 these 200 wheats had been so closely culled out that only the eight best yielding kinds were grown at University Farm. To still better decide among these, small amounts of each kind were made into flour, and the flours were subjected to careful test by the methods known among milling experts as the "color test," the "gluten test" and the "baker's sponge test." Taking the re-

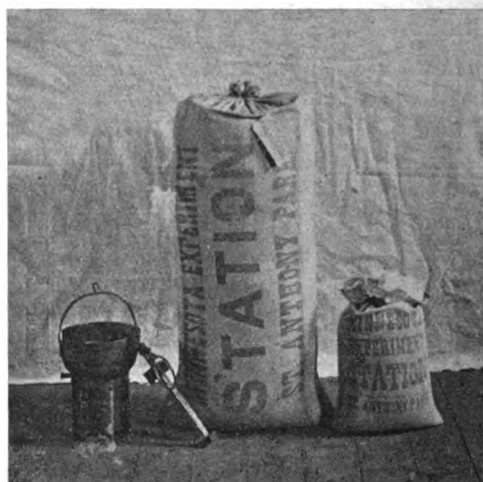


Fig. 243. Wheat as threshed from one plot. Small bag contains wheat saved for pure seed. The brass kettle at the left with its steelyard is used for testing the weight per bushel of the wheat.

sults of these tests of the flour in connection with the data on yields, grade, liability to lodge, etc., through the several years, the list of the eight best wheats out of the original collection of 200 varieties was reduced to four for planting at University Farm in 1898. Prof. Shepperd still retains others of these varieties at the North Dakota station.

In Table XXI. are collected all the yields of all the more prominent varieties for each year at the several experiment stations and farms. In a few cases the yields here entered have not been under-

sufficiently uniform conditions to be comparable, and have not been used in the summarized tables following.

In Table XXII. are collected all the yields of the best eight varieties above mentioned for the years 1892 to 1897, inclusive, at the several stations and farms as heretofore noted.

In Table XXIII. are given the averages of the eight comparable yields, (column 3), of the best eight varieties out of 200, as given at the top of Table XXI. This table was made up in the winter of

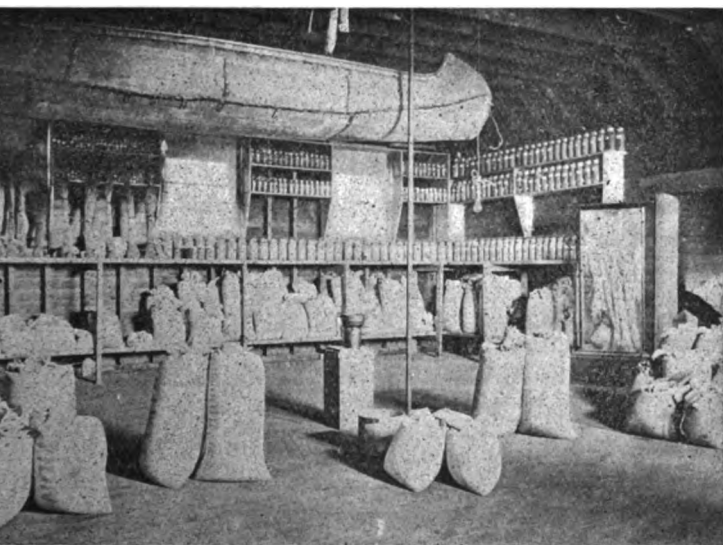


Fig. 244. The Seed House where are Stored the Samples of Varieties.

1897-8 that the list might be still further reduced by discarding the less desirable before seeding time in 1898. In a similar manner the data on grade, weight per bushel, per cent. rustiness and per cent. lodged of the several crops are here averaged and tabulated.

Space will not permit the publication of all the tables, but the averages only as given in Table XXIII. are sufficient to illustrate their use in deciding the relative values of the several varieties.

A careful inspection of this table will show why four of these varieties were discarded, retaining as the best four the following:

Minn. No. 51, Haynes' Blue Stem; Minn. No. 66, Power's Fife; Minn. No. 105, Glyndon 711; and Minn. No. 146, Bolton's Blue Stem.

Grading Wheat is the passing upon its commercial value for milling purpose. The grades (column 4) in Table XXIII. were determined for the first few years by professional grain inspectors from the State Grain Inspection force, who, from daily passing upon the grades of commercial grain, are expert judges. During later years the two who subscribe to this bulletin have done most of the grading. The public inspector's experience is nearly all with the two classes of wheat, Fife and Blue Stem. It was found that he passed judgment on other varieties by standards of color, hardness under the teeth, and of other characters, which were especially applicable in comparing the samples of the two varieties most common in our markets. When varieties from a foreign country or varieties newly bred in Minnesota, which differed in appearance, came before the inspector, he would often place them too low, or too high, merely because of a lack of the amber color or of the flinty, transparent inside common to the standard wheats, which in his long daily experience had become his ideal of good wheats. The writers, knowing each wheat year after year, and having in mind the facts brought out by actually milling them, could better place the grade, though not so well trained in the empirical yet fairly satisfactory art of grading the two wheats commonly sent to our terminal markets. These

TABLE XXII.—Best Eight out of Two Hundred Collected Wheats.

Grown at	Names.									
	Blount's Hybrid, No. 15, Minn. No. 13.	White Russian, Minn. No. 19.	Haynes' Blue Stem, Minn. No. 51.	Power's Fife, Minn. No. 66.	Rio Grande, Minn. No. 72.	Glyndon 711, Minn. No. 105.	Glyndon 753, Minn. No. 116.	Bolton's Blue Stem, No. 146.		
Fargo, 1892.....	17.3	17.7	16.7	21.3	14.7	23.3	14.7	*21.1		
Fargo, 1893.....	12.8	11.9	12.9	15.1	13.4	10.0	14.3	17.0		
Coteau, 1894.....	23.8	23.0	*20.8	19.8	13.6	21.4	19.3	21.0		
Coteau, 1895.....	23.5	21.5	24.7	22.8	20.7	22.8	20.6	20.0		
University Farm, 1895.....	29.0	33.2	21.6	26.3	29.3	31.8	31.5	35.0		
Fargo, 1896.....	17.0	19.7	23.4	22.5	18.0	18.2	17.0	23.0		
University Farm, 1896.....	21.2	24.8	24.6	21.4	20.2	21.4	21.0	25.0		
University Farm, 1897.....	15.5	16.3	20.4	17.4	15.2	17.8	19.7	21.0		
Averages of Eight trials.....	20.0	21.0	20.6	20.8	18.1	20.8	19.8	24.0		

TABLE XXIII. Wheats. Best Eight of 200 Collected Prior to 1894—Yields, Grades, Quality of Flour, Etc.

Variety.	Minn. Number.	Yield per acre. Av. of eight trials.	Grade. Av. of seven trials.	Weight per Bushel. Av. of four trials.	Per cent. Rust. Av of two trials.	Per cent. Lodged. Av. of two trials.	Quality.	Gluten test, av. of two trials.			Baker's sponge test average of two trials.					Per cent. of Water absorbed by Flour.
								Per cent. Dry.	Grams Water held by each Gram Gluten.	Total.	First Risc.	Second Risc.	Second Risc. and 2d Risc.	Rise for each gram of Gluten.		

Blount's Hybrid No. 15.	13	20.0	84.0	55.4	15.0	15.0	75.0	17.3	1.94	122	63	169	1050	775	62.8	44.9	90.0
White Russian.....	19	21.0	77.1	55.0	16.0	18.5	77.5	14.5	2.03	90	72	162	725	550	53.3	46.4	82.5
Haynes' Blue Stem.....	51	20.6	85.0	54.0	12.5	7.5	82.5	15.7	2.04	98	68	166	1000	850	59.1	54.4	84.0
Power's Pife.....	66	20.8	89.9	55.4	12.0	15.0	87.5	16.5	2.21	101	53	154	1075	850	58.4	51.6	88.5
Rio Grande.....	72	18.1	81.4	56.8	20.0	12.5	72.5	17.2	2.08	107	92	199	1125	600	50.2	34.6	87.5
Glyndon 711.....	105	20.8	87.0	54.0	19.0	23.5	82.5	17.0	2.26	111	64	175	1175	800	57.9	47.1	90.5
Glyndon 713.....	116	19.8	85.4	54.5	15.0	24.0	82.5	16.7	2.16	115	86	2.1	1200	750	58.4	44.9	90.5
Bolton's Blue Stem.....	146	24.2	88.6	52.8	8.0	12.5	85.0	16.4	2.08	115	78	191	1163	800	59.9	40.7	87.5

* Average of five trials. † Three trials.

grades have a comparatively limited value in the tables because the gluten test and the baker's sponge test, described further on, tell in figures what the inspection attempts to estimate.

These grades have been here expressed in percentages rather than in commercial grades. These percentages are not convertible into commercial grades. In grading each wheat the quality of flour, as previously determined by milling it and subjecting it to the color test, the gluten test and the baker's sponge test, is taken into consideration. Thus the outward appearance of the particular sample of wheat is not taken as the sole measure of the quality of that particular kind of wheat. In case one wheat is poor in quality and quantity of its gluten, and if the sample is also poor in appearance, its grade is placed very low; or if the appearance of the sample is indeed very good it is given only a poor grade. An effort is made to let the grade represent the milling value of the wheat. With our present facilities, we are able to satisfactorily determine the quality and quantity of gluten in the wheats. The quantity of patent flour and the quantity of lower grade flours which the several grades of each variety of wheat will make should also be determined. For this purpose a four or six roll test mill is needed. With such an addition to our apparatus, we could determine more accurately the value of each variety of wheat, and its particular use as a mixer in combining it with other wheats to make flour of a given standard quality. Most of the factors which must be taken into consideration in grading wheat can be reduced to values expressed in figures. Among these factors are purity, weight, size of berry, color, plumpness, condition of bran; and where the wheat is of a known variety, and milling tests have been made, the percentage of gluten, the quality of gluten and the quantity of flour which a hundred pounds of the wheat will make may all be given their place in the estimate of value. By determining the relative importance of these several factors, grading wheat might be reduced to more nearly a mechanical basis, though the expense might be prohibitive in commercial dealings. In case of disputes simple

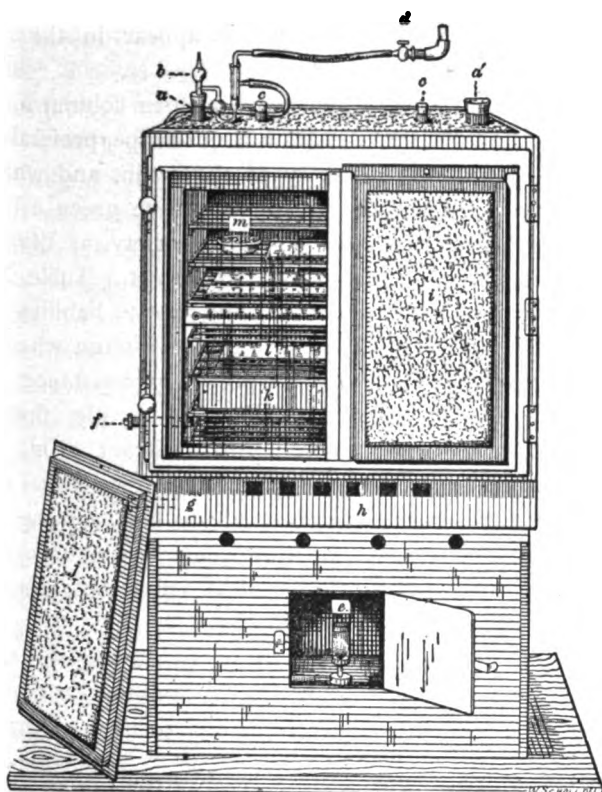


Fig. 245. Standard seed germinating chamber, used by the U. S. Department of Agriculture and American experiment stations (front view with one door slide removed); a a, openings into water jacket; b, thermoregulator; cc, openings into chamber; d, gas entrance tube; e, micro-bunsen burner; f, gas exit; h, ventilator; i, j, door slides; k, pan to hold porous saucers, etc.; l, blotter test; m, porous saucers with sand test.—[U. S. Dep. Ag. Circular No. 84.]

milling tests also might be employed to determine the value of wheats. The subject is one of large importance, and experimentation might lead to methods of inspection which are more accurate and yet inexpensive and practical.

The Weights Per Bushel have usually been taken as the grain came from the threshing machine, or where further cleaning was necessary, as it was cleaned sufficiently for market. The ordinary brass kettle used by official inspectors is used, duplicate weights being taken and averages made. These for the

several years have been averaged and appear in the several tables.

The Diseased or Rusted Condition, given in column 6, Table XXIII., is best noted before the grain is quite ripe, preferably one to two weeks before the maturity of the grain, and while the middle and lower leaves are yet full of active green cells. In taking these notes on rust some standard variety, as Blue Stem or Fife, is used, and all others compared with it. Table XXIII. does not show a very wide variation in the relative liability to rust of the best eight varieties. But some of the foreign wheats collected since 1894 show a much less power of resistance to this disease, as is shown in Table XXVIII. As a rule, the better yielding varieties are comparatively rust resistant. Or, it may be better to say that only varieties which have good rust-resisting power can yield well and have been able to hold a place in this list of eight best out of 200 kinds of wheat originally collected. Rust is always present and attacks all varieties, but some resist it with much greater power than others.

The Liability to Lodge has been noted during those years where the rainfall has been sufficient to cause more or less of the wheat to fall down. While yield and quality of grain are the main factors to be definitely measured in variety tests, the ability to stand up well and other peculiarities should be recorded. Farmers who have heavy, rich soils, especially need varieties of grain which have stiff straw. Here, also, one variety is used as a standard of comparison, and the proportion of the plants which have fallen down are expressed in percentages as in column 7 in Table XXIII.

TESTING THE QUALITY OF FLOUR FROM VARIETIES OF WHEAT.

The quality of wheat of new or unknown varieties cannot be fully determined by mere inspection. As between various samples of the same known variety, but grown under different conditions, the state inspectors and experienced grain dealers are able to judge closely the relative milling values. But there is no known empirical method of passing correct judgment upon varieties which are new to the inspector, nor of comparing their

ing value with our commonly grown Red Fife and Blue Stem varieties. This has been abundantly shown in our grading, where we have had judges of large experience undertake to grade any varieties:

If we should disseminate, and cause to be grown a new variety of wheat which would be different in appearance from our common kinds, the inspectors would need to know of its relative milling value, and they might need to make for it an entirely new class. Our Minn. No. 292, a Risting Fife in-cross, will be a case in point if its record for good yield is continued and enters the list chosen to be disseminated to the farmers of the State. It is a pure Fife wheat in that both of its parents were the Red Fife plants, yet this cross is very much lighter in color of berry than its parent variety. Any new wheat would be an additional value if combined with high milling qualities like the color, hardness, smoothness of bran and general appearance which would cause it to conform to the highest present market standards. But if the wheat has superior intrinsic worth it must stand upon its merit, and the standards or fashions of the market will need to change to suit the wheat. Fortunately, so far most of our best new wheats are Fife or Blue Stem breeding, and in appearance and in quality are quite like their parents.

In seeking a knowledge of the real milling and food qualities of the numerous varieties under trial, the baking experts of the large mills were consulted, and also Prof. Harry Snyder, Professor of Agricultural Chemistry. Tests were decided upon for each variety, and for that purpose each was ground into flour. Mr. C. E. Foster, baking expert of the Consolidated Milling Company of Minneapolis, kindly offered assistance in milling and testing the wheats, and most freely advised and aided in deciding plans which would be uniform and satisfactory. We were thus enabled to test the flours of the collected wheats in Table XIII., in February, 1898, and also the other wheats that were grown. In all, fifty-three varieties of wheat grown on University Farm were thus milled and tested, and of these thirty-

three duplicates which had been grown at Northwest Farm at Crookston in 1897 were milled and tested, making a total of 86 samples.

METHOD OF MILLING SAMPLES OF VARIETIES OF WHEAT.

The Consolidated Milling Company of Minneapolis kindly placed at our disposal their two small test roller mills in which to grind

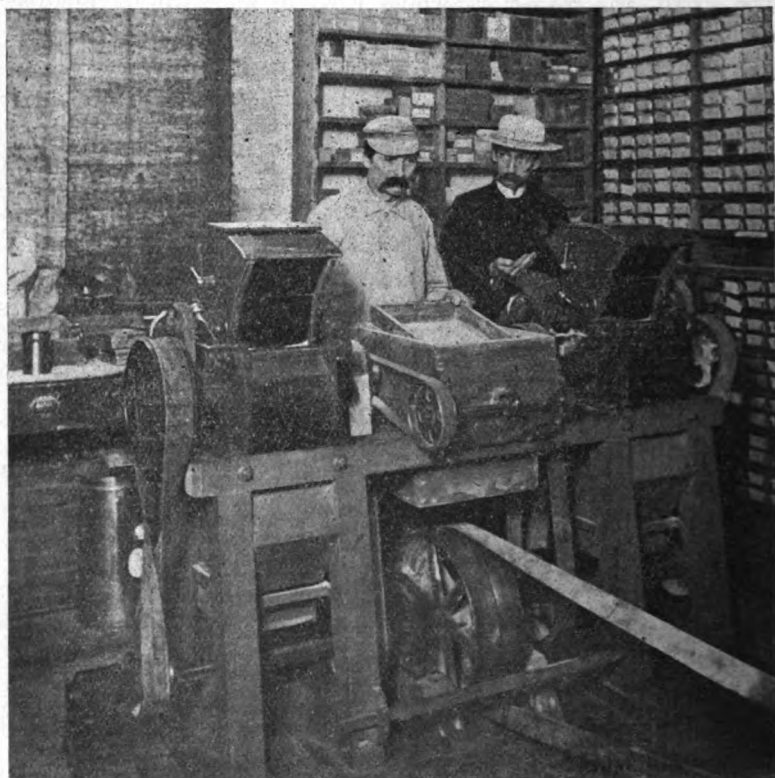


Fig. 246. Milling the Varieties of Wheat.

the samples of wheat. See Fig. 246. These mills are suited to grinding small quantities of grain. Each of the two mills has rolls six inches in diameter and six inches long. The first mill has corrugated rolls and the second smooth rolls. These miniature mills are very simple, consisting of little else than the

rolls. The ground wheat falls into a box. It is then poured into a sieve or simple plan-sifter which is shaken by machinery. Silk or wire sieves of such sized mesh that only the finer particles of flour will pass through are used, and the bran and coarser particles from the inside of the kernels are again passed through the rolls, further removing the floury particles from the bran, and making them sufficiently fine to pass through a fine silk cloth sieve.

The operator's judgment is used as to the closeness of removing the flour from the bran, since some varieties mill easier than



Fig. 247. Making the Color Test of the Flour from each Variety of Wheat.

others. No attempt is made in these tests to closely separate from the flour the finely broken particles of bran which injure its color. To do this effectually, it would be necessary to carry some of each variety through the complete process of the modern roller mill with its extensive system of "rolls" and reels or shaking sieves.

Since comparisons of flour of each new wheat with the flour of our common Fife and Blue Stem varieties were the objects sought, rather than making perfect flour from each, it was found that this could be done by milling small amounts and making the tests with comparatively small quantities of flour.

Milling the Test Samples.—A quart or more of each kind of wheat having been cleaned, it was run through the test mill. An ounce of this flour was weighed out for the gluten test, and 100 grams for the baker's sponge test. In the gluten test the



Fig. 248. Making the Gluten Test.

essential facts sought were the amount of gluten and its strength, while incidentally its color and other qualities were noted. In the baker's sponge test the flour was subjected to a practical trial of its ability to rise in a dough when worked down and required to again rise in the loaf.

The Gluten Test was carried on as follows: An ounce of the flour was weighed out. Water was added and the flour kneaded into a stiff dough. This was worked considerably so as to bring

all the gluten into active contact. Then the mass of dough was held under a stream of water and gently pulled and kneaded. The dough was thus manipulated until all the parts had been turned out and exposed to the running water, and all the starch grains had been disentangled from the fibrous mass of gluten, and washed away, as shown by the wash water no longer containing a sediment of starch.

To avoid the loss of small portions of gluten, which might break loose, a hair sieve was kept under the stream of water, and any detached portions of gluten were gathered up and again placed with the general mass.

When this gluten had been washed clean of starch it was dried to a standard dryness. This was done by continuously pulling and kneading it in the hands, frequently drying the hands on a towel, until the free portions of water had been removed. This mass of moist gluten was then weighed, that the difference might be found between the wet weight and the dry, water-free substance, weighed later on, thus finding the power of the gluten to hold water. Notes were made on this wet gluten as to its color, and especially as to the strength of the gluten. It was stretched out into threads, the better gluten stretching out into longer and finer threads than the poorer, which breaks off more squarely. It was then laid in a round mass upon a stiff card. The stiffer the gluten the higher it lies in a more nearly globular mass; and the poorer the gluten, the more it "runs," or spreads out on the card. This method, while somewhat empirical, is reasonably accurate, and an expert operator can tell by it much regarding the quality of the gluten of a given variety of wheat. The varieties with stiffer, tougher gluten will rise high in the loaf, and as a rule will retain their power of rising after the dough has been worked down one or more times. And the varieties with gluten which runs freely, and easily breaks upon being stretched, make a loaf which will not rise high, rises poorly after it has been "worked down," and makes withal a "runny" dough that creeps out over the edges of the pan rather than rises into a well formed loaf. Tables XXIII. and XXIV. bear out these

general statements, though the various tables giving gluten and baker's sponge tests do not in quite all cases show a uniformity of results from these two methods as to the quality of the gluten.

The moist gluten was dried in a temperature of 212 deg. F. until its moisture had been all driven off. It was then weighed (col. 9 in Table XXIII.), and the difference between the dry and the wet weights was taken as the amount of water held by the gluten (col. 10 in Table XXXIII.), and from this was figured the amount of water held by each gram of gluten. See Fig. 248.

The Color Test is made as follows: The samples of flour are placed in adjacent masses on a rectangular plate of glass about three by ten inches in size. Each mass is smoothed down with a steel spatula so as to present a smooth surface. An extensive series of colored glass slabs is used. The colors of these glasses are delicately graded from light to gray, and to brown, each color being marked with a certain percentage or scale. The flours are then matched with the glasses and the color of that glass recorded which corresponds with the color of the flour. See Fig. 247.

The Baker's Sponge Test was performed as follows: One hundred grams of flour were weighed out in a wide porcelain dish or an earthenware bowl holding a pint or more. See Fig. 249. Part of the water needed to make the flour into a dough (usually about 65 cc.) was then measured out from a burette. Into this was dissolved five grams of sugar and five grams of compressed yeast. The flour was stirred into this water with a steel spatula, and more water was added until the whole was kneaded into a dough of standard consistency or "stiffness". The cubic centimeters of water required by a given sample of flour were then expressed in percentages of water taken up by each one hundred grams of flour. (See column 8, Table XXIII.)

The dough was then placed in tubes about four inches in diameter, which were graduated into cubic centimeters. These tubes were then set in water at 90 deg. F., and the dough allowed to rise. It was constantly watched until it reached its full height and fell, when the time required to rise and its volume expressed

cubic centimeters were recorded. The tube was left in the water bath until the dough again rose to the full height its remaining strength was capable of, when the time required and the volume were again recorded. These facts are noted in Table III., under columns 12-16 inclusive.

By dividing the volume of loaf to which 100 grams of flour could rise by the percentage of gluten in the flour, the volume of loaf produced by each gram or percentage of gluten was found. Since 100 grams of flour were used and the specific grav-

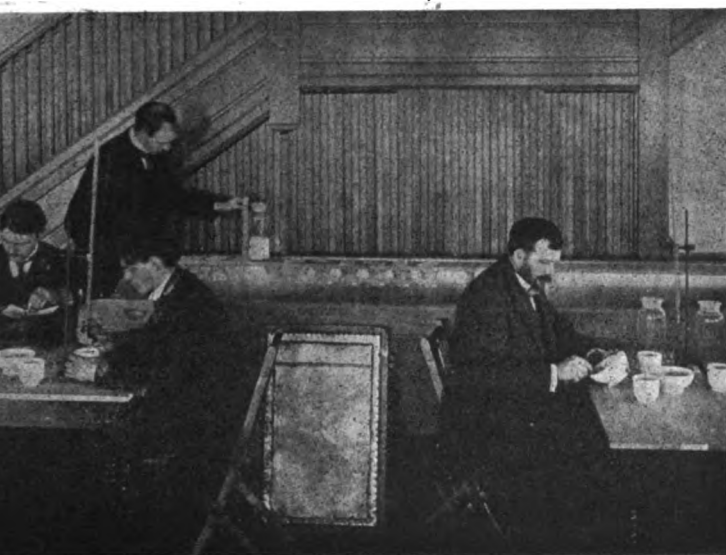


Fig. 249. Making the Baker's Sponge Test of Varieties of Wheat.

of the gluten is not far from unity, it may be said that these figures represent the number of times a gram of gluten from each of the several kinds of wheat will expand. Thus, flour from Bolton's Blue Stem wheat contained only 16.4 per cent. of gluten, yet dough from a hundred grams of flour rose the first time to a volume of 1163 cc., and each gram of gluten produced sixty times its volume of loaf. During the second rise

it rose to a volume of 800 cc., each gram of gluten producing forty-nine times its volume of loaf.

Rio Grande wheat, on the other hand, had a larger percentage of gluten, 17.3 per cent. But this was of poorer quality. The loaf rose nearly as high the first time as that from flour of Bolton's Blue Stem wheat, but there being a larger amount of gluten present, each gram of gluten produced only fifty times its volume of loaf, while in the case of Blue Stem wheat each gram produced sixty times its volume. In the second rise, the gluten from the Rio Grande flour did not show good "staying" qualities, and produced only thirty-five times its volume of risen loaf. The volume of rise produced by each gram of gluten is shown in columns 17 and 18 of Table XXIII.

The gluten test and the baker's sponge test were each carried out in duplicate with each variety of our best wheats, one sample of which was grown at University Farm near St. Paul, and the other at Northwest Farm at Crookston, nearly three hundred miles to the northwestward, and under very different conditions of soil and climate, giving four tests to each variety, the results of which have given satisfactory comparisons. The results of the gluten tests and the baker's sponge tests, taken in connection with the average of eight yields (col. 3, Table XXIII.), give facts which were used in further reducing the list of the wheats retained from the two hundred varieties collected prior to 1894.

RELIABILITY OF MILLING TESTS.

The milling tests to which these varieties of wheats were subjected are not new nor experimental in their principal features. Expressing the amount of rise from each gram of gluten, as in columns 17 and 18, Table XXIII., is a new way of indicating the quality of the gluten present in a given sample of wheat. This method of expressing the strength of the gluten is especially useful for the second rise. It shows whether the gluten has the ability to endure and will repeatedly rise when the loaf is kneaded down. In Table XXIV. are grouped the principal results from Table XXIII., giving the facts relative to the eight best yielding varieties of two hundred wheats collected prior to 1894. It so

opens that these varieties give considerable range in quantity of gluten present and in the quality of the gluten, thus giving opportunity to compare the two methods of determining the strength of the gluten. In column 5 is given the quality of the gluten as determined by Mr. Foster in the gluten test described on pages 347-349, using a percentage comparison. The eight varieties are here arranged in the order in which Mr. Foster placed them, the range being from 87.5 per cent. for the best, down to 72.5 per cent. for the poorest, flour. In column 6 are given the coefficients of expansion as determined by the averages between the

TABLE XXIV.—Comparing the Gluten Tests and Baker's Sponge Test

VARIETY.	Yield per Acre Average of 7 trials.	Per cent. of Gluten Av. of 2 trials.	Quality of Gluten Av. of 2 trials.	Av. of 1st and 2d Rise for 1 gram of gluten, 2 trials.	Av. of 2d Rise for 1 gram of gluten, 2 trials.	Average of Best four and Poorest four wheats com- pared.		
						Quality of Gluten.	First and Second Rise.	Second Rise.
2	3	4	5	6	7	8	9	10
Power's Pile.....	20.8	16.5	87.5	58.4	51.6	.....	.....	.....
Bolton's Blue Stem.....	24.9	16.4	85.	58.9	48.7	.....	.....	.....
Haynes' Blue Stem.....	20.6	15.7	82.5	59.1	54.3	.....	.....	.....
Glyndon 711.....	20.8	17.0	82.5	57.9	47.1	84.4	58.4	50.5
Glyndon 753.....	19.8	16.7	82.5	58.4	44.9	.....	.....	.....
White Russian.....	21.0	14.5	77.5	53.3	46.4	.....	.....	.....
Blount's Hybrid, No. 15.....	20.0	17.3	75.0	52.8	44.9	.....	.....	.....
Rio Grande.....	18.1	17.2	72.5	50.2	34.6	76.9	53.7	42.7

times of rise the first and second times, divided by the amount of dry gluten as found present by Mr. Foster.

It will be seen that, with the exception of the first and third, which are reversed, the flours stand in their power of rising, as shown in this test, in the same order of superiority in which they were placed by Mr. Foster. Taking the second rise alone, there is nearly the same relation shown. In other words, these two methods correspond closely, and it is fair to presume that each, in a general way, is nearly accurate. These tests do not in any means make a complete test of the milling qualities of the wheats. Numerous actual baking trials, milling the wheats in

quantity, alone and in mixture, will be necessary before we have a full knowledge of the quality of any wheat. These simpler tests, however, seem practical in aiding to throw out the less desirable varieties of wheats, that our limited time and means may be spent on the comparatively few which are most promising.

By means of the comparisons we were at once enabled to discard one-half of the best eight wheats of our earlier collections. (See Tables XXIII., XXIV. and XXV.) Minn. No. 72 Rio Grande, easily goes to the foot of the list, being the poorest of the eight in yield and poorest in quality of gluten, and especially poorest in the ability of its dough to rise a second time.

Blount's Hybrid, No. 15, may rightfully be placed next to the lowest on account of the poor quality of its gluten, though it averaged slightly better in yield than Glyndon 763, and as much as Haynes' Blue Stem, one of the four wheats chosen to remain in our preferred list of varieties.

It will be observed that both Rio Grande and Blount's Hybrid No. 15 have an unusually large percentage of gluten, being the richest in these most valuable food substances of any of the eight varieties given in Tables XXIII. and XXIV. But they are without that quality of gluten which enables the baker to make a light loaf; consequently the nutrients cannot be well utilized, and the miller cannot afford to pay a good price for the wheat.

White Russian is excelled in yield only by Minn. No. 146, yet for two reasons it should have the place assigned to it by Mr. Foster's estimate. It lacks both in the quantity and quality of its gluten, being poorest in amount of gluten of any of the eight wheats; i. e., 14.3 per cent.

Glyndon 753 stands highest in the list of the four discarded wheats, and is nearly equal to Minn. No. 105 and Minn. No. 51.

THE BEST FOUR WHEATS OF 200 COLLECTED PRIOR TO 1894.

Of the best four wheats, Minn. No. 146 easily stood at the head. It yielded for the several years an average of 3.4 to 3.6 bushels more than each of the other best four wheats; the per cent. of gluten it contained was excelled in the two trials by Minn. No. 105; its quality of gluten, as shown by the gluten test

TABLE XXV.—Yields of Best Four of 200 Wheats Collected Prior to 1894.

	VARIETY.	Fargo, 1892.	Fargo, 1893.	Coleau, 1895.	University Farm, 1895.	Fargo, 1896.	University Farm, 1896.	University Farm, 1897.	University Farm, 1898.	Northeast Farm, 1898.	North Dakota, 1898.	Footings.	Average of 10 Yields.	Average of all kinds and all yields.
Column in Book 108.....	.....	2	3	8	10	11	12	14	17	19	22	224.1	22.4	.....
Minn. Number 51.....	Haynes' Blue Stem.....	16.7	12.9	24.7	21.6	23.4	24.6	20.4	23.3	23.0	33.5	224.1	22.4	.....
Minn. Number 66.....	Power's Blue.....	21.8	16.1	19.8	26.3	22.5	21.4	17.4	24.3	20.7	32.0	220.5	22.0	.....
Minn. Number 105.....	Glyndon 711.....	23.3	10.0	22.8	31.8	18.2	21.4	17.8	22.3	16.7	32.9	214.8	21.4	.....
Minn. Number 146.....	Bolton's Blue Stem.....	21.2	17.8	20.0	36.3	23.2	26.1	21.6	22.6	19.3	36.3	241.2	24.1	22.6

and by the second rise in the sponge test, was poorer than that of Minn. No. 66, while its strength of gluten in the first rise excelled that shown by any other wheat. Among the other three wheats there is not much choice, as shown by Table XXIV. While the gluten test placed Minn. No. 66, Power's Fife, highest in quality of gluten, Minn. No. 51, Haynes' Blue Stem, showed gluten of greater staying quality in the second rise of the dough. Minn. 105 had a higher percentage of gluten than either 51 or 66, but its gluten showed a lack of endurance in rising a second time.

We have been surprised that from so many wheats collected as the best from countries which are our competitors in spring wheat sections of the world we have found nothing so good as our best samples of home-grown Blue Stem and Fife wheats. These experiments have greatly added to our respect for these two hardy classes of wheat, and to our faith in their continued usefulness in Minnesota and surrounding states. That these wheats have so successfully met all newcomers under the varying conditions of these trials, is good proof that our hard wheats are not "running out," and that new seed need not be procured from somewhere sufficiently "far off" to mystify.

We have thus secured a standard of yields with which to compare our best wheats on experiment station lands, not especially rich nor manured with special fertilizers, but simply well farmed. The four wheats thus used for standards of comparison averaged about 22.5 bushels per acre, as shown in Table XXV. It is the ambition of the experiment station to procure, or to create by breeding, varieties which will increase this yield on these soils to an average of 28 bushels per acre, other conditions remaining as now, and to disseminate such seed throughout the state, that the yields for farmers may be proportionately increased. That this can be done there seems no reason for doubt, though the time required to accomplish this important result may be long.

Twenty-three bushels per acre is a larger average by several bushels than is secured by farmers of the state from seed similar to these best varieties. With a better system of field management, providing for crops preceding the wheat which will

prepare the soil for the wheat, with live stock to make more manure, and with better methods of tillage, farmers can approach and even surpass on good farms the average yields secured on the experiment farms. No doubt a greater increase over our present average yields, of which no one is proud, can be secured by better tillage and a proper rotation of crops than will come from the introduction of new or improved varieties. Our farmers can bring average yields of common Fife and Blue Stem wheat from 15 to 22 bushels by good farming just as well as the station has done. If the station can then furnish them with Fife or Blue Stem or cross-bred varieties so improved as to raise these average yields five bushels higher, profits will be very greatly increased. It is not expected that such results will come at once. But that patient experimenting, and patient, extensive educating will eventually win, seems possible.

BEST BLUE STEM AND BEST FIFE VARIETY OF 200.

The question yearly arises in our experiment work as to which varieties shall be retained for use and increased for dissemination. In connection with the breeding of wheat, it is necessary also to know which are the best kinds of wheat to use as foundation stocks in the attempt to make new varieties. Table XXV. gives the most fairly comparable yields of the four best yielding wheats collected. The average yields, grades, weights per bushel and milling tests of these four wheats to date afford useful comparisons. In yield, Minn. No. 146, Bolton's Blue Stem, is still in the lead, 1.7 bushels; Minn. No. 51, Haynes' Blue Stem, stands second; and Minn. No. 66, Power's Fife, third; while Minn. No. 105, London 711, stands last in yield.

Bolton's Blue Stem, Minn. No. 146, also ranks best in grade. Power's Fife, Minn. No. 66, ranks best in weight per bushel. Haynes' Blue Stem showed the greatest ability to resist rust and lodged least of all varieties. Minn. No. 105, London 711, showed a bad tendency to lodge. Minn. No. 66 and Minn. No. 105, Fife wheats, have half of 1 per cent. more gluten than the two Blue Stem varieties. The quality of the

gluten in Power's Fife, Minn. No. 66, was estimated as superior in the gluten test, but this was not sustained by the baker's sponge test, where it stood lowest of the four wheats in the amount of rise of dough from each gram of gluten. In total value per acre, Minn. No. 146, Bolton's Blue Stem, stands out as the best for use, and it is being extensively used for a foundation stock in the production of new varieties of wheats.

RUSSIAN WHEATS COLLECTED IN 1893-4.

In 1893 and 1894, a number of wheats were collected through our American consuls and from seed dealers in Russia. These were grown in small plots in 1894. In all cases there was a mixture of varieties, and hand sorting was resorted to, the several

TABLE XXVI.—Yields of Russian Wheats Collected in 1893-4.

Russian Names.....	Nicopol Girca No. 1	Nicopol Girca No. 3	Kocharka No. 4	Odessa No. 6	Odessa No. 6	Standard Wheats			
	195	196	197	198	199	66	146	163	169
Minn. Nos.									
Yields at									
University Farm, 1897.....	17.6	15.4	19.8	19.8	15.4	17.4	21.5	19.9	24.3
University Farm, 1898.....	14.2	9.7	18.3	17.3	23.2	24.0	22.5	25.0	26.3
Average Yields.....	15.9	12.5	19.1	18.6	19.3	20.7	22.0	22.5	25.3]

types being picked out of the bundles of harvested grain. Nine of the most promising of these wheats were selected for field variety tests. In 1898, four of these were discarded. In Table XXVI. are given the yields per acre of field trials of the remaining five varieties at University Farm in 1897 and 1898.

Minn. Nos. 195 and 196 have since been discarded without further test, because of their inferior yield.

In Table XXVII. are given the yields, grades, weights per bushel and the quality of the grain for milling purposes of the remaining three Russian varieties. Bolton's Blue Stem and Power's Fife are placed in the table, with their yields, etc., compiled, to serve as standards for comparison.

is plainly shown that no varieties of especial promise have gained from these later importations, and again we have had to find North European varieties of hard wheat which are new to our commonly used varieties.

WHEATS COLLECTED IN 1895 AND 1896.

Table XXVIII. are tabulated the results of trials of wheats collected in 1895 and 1896. In some instances they are original stocks of wheat from which we have bred new varieties, and these are again planted, that their newly originated progeny may be directly compared with the foundation stocks. Such parent varieties are Nos. 165, 168, 172, 294, 475, 476, 477, 479. Nos. 183,

TABLE XXVIII.—Russian Wheats, Results of Tests at Univ. Farm in 1898.

Names of Russian Varieties.	Yields per Acre.	Weight per Bushel.	Per cent. Gluten.	Quality of Gluten.	Baker's Sponge Test.					
					Time, M.		Volume of Rise.			
					Av. of 1st and 2d Rise.	2d Rise.	Water absorbed by flour.	1st Rise.	2d Rise.	From one Gram Gluten.
										Av. of 1st and 2d Rise.
										2d Rise.
No. 4 Kocharka.....	18.3	60.5	10.4	78	86	40	89	950	600	74.5
No. 6 Odessa.....	17.3	57.5	9.1	85	83	34	71	750	650	86.4
No. 6 Odessa.....	23.2	59.5	10.2	65	74	28	74	1000	550	73.5
Standard Varieties										49.0
Lowry's Pile.....	24.0	59.0	12.8	98	111	104	72	950	625	60.8
Colton's Blue Stem.....	22.5	59.5	11.2	85	127	125	74	1075	600	79.5
Lyndon 811.....	25.0	56.5	14.4	98	97	73	73	1050	725	61.1
Haynes' Blue Stem.....	26.3	57.5	11.9	95	75	27	75	1100	600	68.9

274, 275, 497, 457 and 458 are varieties which have been brought to our attention by parties interested in them.

SAUNDERS' CROSS-BRED WHEATS, RECEIVED IN 1895.

In 1895, Dr. Wm. Saunders, Director of the Dominion Experimental Farms, Ottawa, Can., sent the station five of his new cross-wheats. These were tried in comparison with our standard varieties. The results of these trials are collected in Table XXIX., but Minn. Nos. 185 and 188 are discarded from further trial. Minn. No. 188, Preston, gives promise of large yield with good quality, exceeding in yields most of our best collected varieties. Minn. No. 185, Advance, also yielded well, and proved to

TABLE XXVIII.—Wheats Collected in 1895 and 1896.

Minn. No.	NAMES OF VARIETIES.	YIELD		Average	Weight per Bushel		Per Cent. Lodged		Per Cent. Rust		Gluten 1898		BAKER'S SPONGE TEST					Water Absorbed.			
		1897	1898		1897	1898	1897	1898	Quality	Amount	First Rise	Second Rise	Volume of Rise								
													First Rise	Second Rise	From each gr'm gluten and 2d 1st						
																Time	Volume of Rise				
165	Wellman's Fife	16.3	24.7	.....	92	56	59.5	0	0	7	95	12.6	145	94	1125	675	69.4	55.5	73		
168	Glyndon 811	16.75	24.0	20.4	78	59	59	20	0	10	80	10.0	111	13	800	650	72.5	65	72		
183	Lost Nation	14.12	22.2	18.2	80	55	59	20	0	12	89	9.7	114	15	900	650	79.9	67	69		
184	North Star	14.66	12.6	13.6	73	70	51	56	20	0	14	75	12.4	116	27	1100	550	66.5	44.3	69	
274	Sq. Headed Dwarf of Sicily	14.33	12.8	13.6	78	65	52	56.5	40	0	23	65	10.3	117	59	950	600	75.2	58.2	74	
275	Red Headed May Wheat.	21.25	24.8	23.0	84	90	54.5	59	17	0	9	6	80	11.2	125	85	950	750	75.8	66.9	74
294	Haynes' Blue Stem	22.0	26.6	24.3	84	92	54	58	20	0	12	79	13.9	132	76	1000	750	62.9	53.9	72	
295	Improved Blue Stem	22.0	26.6	24.3	84	92	54	58	20	0	12	79	13.9	132	76	1000	750	62.9	53.9	72	
475	McKissick's Fife	20.35	24.6	22.5	88	90	58	60	15	0	22	95	18.2	121	87	950	750	64.3	56.8	73	
476	Rising's Fife	20.9	26.6	23.7	90	90	60	60	15	0	10	15	13.0	135	68	1050	700	69.1	57.6	71	
477	McKendry's Fife	18.15	23.8	21.0	85	85	60	60	10	11	10	95	12.9	125	65	950	750	65.8	58.1	72	
478	McKendry's Assa. Fife	18.7	23.8	21.0	85	85	60	60	10	10	10	95	12.5	125	65	950	750	65.8	58.1	72	
479	Glyndon 753	18.7	23.8	21.0	86	86	60	60	13	0	10	95	12.5	136	89	950	750	68.0	60.0	73	
497	Haynes' Blue Stem	22.0	27.5	23.7	86	86	60	60	8	0	3	95	12.5	136	89	950	750	68.0	60.0	73	
498	Gehum	12.65	20.5	27.5	86	52	60.5	13	0	12	95	12.4	148	80	1100	700	72.5	56.4	75		
498	Haynes' Fed. Blue Stem	20.5	27.5	24.0	81	86	52	60.5	13	0	2	95	12.4	148	80	1100	700	72.5	56.4	75	
457	Buchan	14.33	.....	.....	78	54	.....	10	0	12	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	
458	Egyptian Fife	17.83	.....	.....	80	54	.....	25	0	11	6	.....	.....	.....	.....	.....	.....	.....	.....	.....	
Standard Collected Wheats																					
66	Power's Fife	17.4	24.0	20.7	83	93	55	59	15	0	12	98	12.8	118	104	950	625	60.8	47.5	72	
146	Bolton's Blue Stem	21.5	22.5	22.0	83	94	53.5	59.5	10	0	9	85	11.2	132	125	1075	600	66.1	53.5	74	
Standard New Wheats																					
163	Glyndon 811	19.87	25.0	22.4	87	93	56	56.5	10	0	11	98	14.4	127	72	1050	725	61.5	50.3	73	
169	Haynes' Blue Stem	24.3	26.3	25.3	85	87	54.5	57.5	8	0	8	95	11.9	123	27	1100	600	71.4	58.8	75	

TABLE XXIX.—Saunders' Cross-Bred Varieties. Received in 1896.

Minn. Nos.	Names of Saunders' Varieties.	Yield per Acre.	Grade.	Weight per Bushel.	Rust, Per Cent.	Lodged, Per Cent.	Gluten Test.				Time.		Vol. of Rise.				Per Cent. Water held by Flour.	
							Quality.	Per Cent. Dry.	Grams Water per Gram Gluten.	1st Rise.	2d Rise.	Total.	1st Rise.	2d Rise.	Av. of 1st and 2d Rise.	2d Rise.		
185	Advance.....	20.6	85	57	13	7	80	18.1	2.07	125	56	181	1175	650	83.7	50.5	84.	
186	Crown.....	18.4	86	57	15	5	87	14.4	2.11	118	56	174	1225	1000	73.3	60.	84.	
137	Stanley.....	13.5	82	56	17	12	78	13.4	2.1	127	52	179	1225	675	72.1	50.8	82.	
188	Preston.....	23.3	85	56	22	7	75	18.1	2.35	125	50	175	1150	725	71.8	54.0	82.	
Standard Varieties																		
51	Haynes' Blue Stem	21.9	90	56	8	5	85	14.4	2.0	117	73	190	1050	675	69.2	51.1	79.	
66	Power's Rife.....	20.7	90	57	11	7	94	15.3	2.7	110	89	199	1025	788	57.8	47.6	81.	
146	Bolton's Blue Stem.....	22.0	88	57	10	5	83	13.9	2.35	121	98	219	1065	750	66.7	54.0	80.5	

Yield of 1897 and 1898 at University Farm.

be a fairly good milling wheat. The three discarded varieties made flour of good quality, especially Minn. No. 186, Crown.

In Table XXX., seven yields of the two wheats still retained are given in comparison with our best two collected wheats and the best two wheats originated in our field crop nursery. Preston is the most interesting and promising variety of wheat procured outside the state, and it bids fair to be a strong rival of our best Fife and Blue Stem wheats. It is being subjected to rigid selection in our field crop nursery, that new varieties may be produced from it, and it is employed as a parent of cross-bred varieties.

TABLE XXX.—Saunders' Cross-Bred Wheats Received in 1895.

Names of Varieties.....	Advance	Preston	Standard Wheats.			
			Collected		New	
			Power's Fife	Bolton's Blue Stem		
Minn. Nos	185	188	66	146	163	169
Grown at						
University Farm, 1896.....	18.7	27.0	21.4	25.1	23.0	25.0
University Farm, 1897.....	18.3	20.6	17.4	21.5	19.9	24.3
University Farm, 1898.....	23.0	26.3	24.0	22.5	25.0	26.3
N. W. Farm, 1898.....	16.0	19.3	18.8		20.3	22.5
N. E. Farm, 1898.....	16.5	15.2	20.7	19.3	14.7	19.3
South Dakota, 1898	13.8	17.2	17.4	17.3	15.4	14.1
North Dakota, 1898	33.0	36.5	32.0	35.3	37.2	38.4
Averages	19.9	23.1	21.7		22.2	24.3

Advance, Minn. No. 185, having failed to keep its average yield up to the best standard varieties, would be discarded but for the fact that stocks of it are being bred in the field crop nursery, and it is desirable to retain the original stock for the purpose of future comparisons with its progeny.

SAUNDERS' CROSS-BRED WHEATS RECEIVED IN 1896.

In 1896 the station received from Dr. Saunders six other cross-bred varieties, which were grown in small plots in that year and given field trials in 1897 and 1898. Four varieties which had yielded poorly in 1897, and were not especially promising at harvest time in 1898, were not threshed separately in the latter year.

TABLE XXXI.—Wheats. Saunders' Cross-Bred Varieties Received 1896.

Minm. No.	Name of Varieties.	Yield per Acre, 1 Trial.	Grade, 1 Trial.	Wt. per Bush., 1 Trial.	Lodged, 1 Trial.	Gluten Test.			Time.			Baker's Sponge Test.				Per Cent. Water Held by Flour.	
						Quality.	Per Cent. Dry.	Grams Water held by 1 Gram Gluten	1st Rise.	2d Rise.	Total.	1st Rise.	2d Rise.	Av. of 1st and 2d Rise.	Of 1 Gram Gluten.		
451	Countess.....	11.0	80	55.5	35	85	15.3	2.20	85	150	235	950	750	5.6	48.6	98	
452	Ladoga.....	12.0	60	49.5	30	65	15.2	2.80	100	85	185	1050	800	60.8	52.4	87	
453	Percy.....	13.3	78	54.0	25	70	17.2	2.13	110	92	202	1300	900	63.9	52.3	92	
454	Dawn.....	17.2	78	53.5	25	70	15.2	2.08	95	90	185	900	700	52.6	46.0	92	
455	Alpha.....	16.2	78	54.0	20	70	16.2	2.11	93	96	189	950	600	48.1	37.0	82	
456	Progress.....	14.6	78	54.0	25	75	17.1	2.06	109	75	184	1150	800	57.0	46.8	91	
Standard Varieties.																	
51	Haynes' Blue Stem.....	20.4	82	53.5	10	75	15.0	1.98	96	75	171	1000	800	54.8	48.7	84	
66	Power's Rife.....	17.4	83	55.0	15	85	15.4	2.13	102	75	177	1100	850	55.1	44.0	90	
446	Bloton's Blue Stem..	21.5	83	53.5	10	80	16.2	2.03	110	70	180	1050	900	58.7	54.2	87	

Table is made from results at University Farm for 1897.

and were discarded. In Table XXXI. are given the results of 1897, together with the results of one milling test.

Minn. No. 454, Dawn, and Minn. No. 455, Alpha, were harvested in 1898, and the results of the three years' trials of these two wheats are shown in Table XXXII. in comparison with the yields of four of our best wheats. Since we have so many varieties of greater promise, it does not seem wise to retain either of these varieties in the tests.

ORIGINAL FIFE AND BLUE STEM VARIETIES VS. BEST NEW WHEATS.

When the comparison of varieties of wheat had continued for some years, and it had become evident that Fife and Blue Stem varieties were better adapted to our conditions than any other

TABLE XXXII.—Best of Saunders' Cross-Bred Wheats Received in 1896.

	Dawn	Alpha	Standard Wheats			
			Collected		New	
			Power's Fife 66	Bolton's Blue Stem 146	Glyndon 811 163	Haynes' Blue Stem 169
Minn. Nos.....	514	455				
Grown at						
Univ. Farm 1896	19.2	17.4	21.4	25.1	23.0	25.0
Univ. Farm 1897	17.3	16.3	17.4	21.5	19.9	24.3
Univ. Farm 1898	17.6	20.5	24.0	22.5	25.0	26.3
Averages.....	18.0	18.1	20.9	22.0	22.6	25.2

wheats we had obtained, it seemed best to try to determine which of these two classes of wheat is superior.

In Table XXXIII. are summarized the yields for 1897 and 1898 of six original stocks of Fife and six of Blue Stem, and with them are placed also, for comparison, three of the most promising new wheats originated in our field crop nursery.

MISCELLANEOUS WHEATS.

Goose Wheat is a variety or class of wheat which the station was urged to test by persons who had taken a casual interest in it. It has been variously named in the current literature as goose wheat, rice wheat, kubanka, ironutka, etc. Statements have been circulated that it would yield 30 to 50 bushels per acre, and that it is a superior crop for stock food. After thorough trials, we deem it unfit for flour, and too poor a yielder for a stock food.

TABLE XXXIII—Original Pife vs. Blue Stem Varieties vs. New Wheats.

Name. Grown at	Pife Varieties.						Blue Stem Varieties.						Best New Varieties.			
	Powers's Pife.	Wellman's Pife.	Wellman's Pife.	Wellman's Pife.	McKissick's Pife.	Rieting's Pife.	McKendry's Assn. Pife.	Haynes', Crop of 1891.	Bolton's.	Haynes', Crop of 1896.	Jackson's Improved.	Haynes', Crop of 1891.	Haynes', Crop of 1896.	Powers's Pife. Selected in 1892.	Glyndon 811. Selected in 1892.	Haynes' Blue Stem. Selected in 1892.
Minn. Nos.	66	165	172	475	476	477	51	146	294	295	295	479	498	149	163	169
Univ. Farm, 1897....	17.4	19.5	20.4	20.9	20.9	18.2	20.4	21.5	21.8	22.0	22.0	22.0	20.5	19.9	19.9	24.3
Univ. Farm, 1898....	24.0	24.7	24.6	26.6	26.6	23.8	23.8	22.5	24.8	26.6	26.6	27.5	27.5	26.5	26.0	26.3
Average.....	20.7	21.2	22.5	23.8	23.8	21.0	21.8	22.0	23.1	24.3	24.3	24.8	24.0	23.2	22.4	25.3
General Average.....						22.0							23.3			23.6

The gluten in its flour has very little strength, and it yields less than our hard wheats.

Ladoga Wheat received much attention a decade ago, especially in the Canadian Northwest. This wheat was used with good results by Dr. Wm. Saunders, director of the Canadian experiment farms, as one of two parent varieties in producing cross-bred wheats. His effort was to produce early varieties suited to the short seasons along the northern borders of the spring wheat belt. Minn. No. 188, Preston, and Minn. No. 185, Advance, (see Tables XXIX and XXX), were thus produced by crossing *Ladoga* with *Fife* wheat, and they both show the *Ladoga* parentage by their bearded character. While these wheats are not especially early, they have proven to be good yielders. (See Table XXI.)

Several trials of *Ladoga* wheat in Minnesota resulted in poor yields of very poor wheat, and this variety was discarded without even a milling test.

Winter Wheat has been grown but little in Minnesota. During recent years several counties in the southeastern part of the state have produced considerable winter wheat of a variety which has generally proven hardy and has yielded about fifty per cent. more than the standard varieties of spring wheat. Minnesota is credited with producing larger yields of winter rye per acre than any other state. If winter wheats could be secured or produced sufficiently hardy to endure the winter and extend the winter wheat belt one or two hundred miles further to the northward, we could expect our average yields of wheat to be materially increased. We have already collected a few varieties, and have commenced breeding some of the most promising ones with a view of obtaining still greater hardiness, as well as the increased yields. Dr. Otto Lugger, entomologist of this station, and Dr. L. O. Howard, chief entomologist of the National Department of Agriculture, question the wisdom of bringing winter wheat northward. They express the belief that the Hessian fly will follow the winter wheat and spread to the fields of spring wheat, and will there cause enough damage to more than offset the value of the increased yields of the winter wheat. This

se of the question will be watched with great interest, and facts may warrant the restriction of winter wheat from certain districts where spring varieties mainly are grown.

NEWLY ORIGINATED VARIETIES OF WHEAT.

In 1892, the breeding of eight of the best varieties of wheat which had been collected by the Minnesota experiment station begun by W. M. Hays, then at the North Dakota experiment station. Four hundred selected kernels of each of the eight varieties, which had been grown at Glyndon, Clay county, the previous year, were planted at Fargo, N. Dak., and a like number on the farm belonging to J. B. Power & Son, Power, Rich-land Co., N. Dak. The conditions being better at Power, and the plants more uniform in size, the selection of plants for "mother" varieties was made from the plots at that place. Besides choosing plants from which to originate varieties by selection, numerous crosses were made both at Fargo and at Power.

THIRTY-ONE NEW WHEATS FROM SELECTED MOTHER PLANTS.

The method of planting and selecting wheat in the field crop every, when first begun in 1892, was crude in many ways. An important feature of dealing with the individual plant in selection was, however, fully recognized, and not only the yield, but the quality, of the grain, and other characteristics, were taken into account in selecting plants to become the mothers of varieties. Four hundred plants of each of eight kinds were placed on very good farm soil, with the surface nicely pulverized. The seeds were carefully chosen from bulk grain,—heavy, "hard" kernels of the larger size being selected. The seeds were planted in hills four by five by eighteen inches apart, making the plots twelve by twelve feet in size. One kernel was placed in a hill. This distance between hills has since been found too great for the best results in wheat breeding,—four by four inches being preferred. The plants were all cultivated until in flower, when the strongest plants were chosen for male and female parents of crosses between several of the varieties. When the grain was ripe the plants used in crosses were harvested, so as to obtain the yields

of the parents of the various cross-bred kernels which had resulted from the cross-pollinated flowers. After the removal of the plants which had been used for parents of crosses, each plot was carefully inspected, and the best ten plants chosen and the spikes from each plant harvested separately. The seeds of each plant were shelled out, and the net weight of the clean grain was determined for each plant. From the eighty plants thus secured, the thirty-one having the largest yields, and of superior quality, were chosen to plant the next season. In 1893, one hundred to four hundred kernels from each of these thirty-one plants were planted at Fargo in a manner similar to the method of planting in 1892. When this wheat was ripe the best ten plants were chosen from each plot, and from these the best plant was selected after weighing the clean grain as in 1892. Thus the best plant was secured for the mother of a plot in 1894, each plot of which traced back through a single plant to one of the thirty-one plants chosen in 1892. The breeding of these thirty-one stocks of wheat was started, and in case of each of those proving most promising has been annually continued to this date. The best plant of one generation thus becomes the mother of all of the one or more hundred plants of the next generation. Since wheat is practically self-fertilized, the "blood" of one plant is kept pure for several generations, and the best one of the progeny of each generation is chosen to become the double parent of the succeeding generation. This more than incestuous breeding seems natural to wheat plants. In a manner similar to that described under the next heading new varieties are produced by increasing the wheat from the mother plant chosen every fifth generation in the line of continuous annual selection.

BEST EIGHT VARIETIES FROM MOTHER PLANTS OF 1892.

In 1893, the best plant was first chosen from each of the thirty-one stocks as above mentioned. Then the poorest one-fourth of the remaining plants was discarded, and the seed from the remaining plants of each stock was saved in bulk. This sample seed was given a variety name, as Minn. No. 163, Minn. No. 164,

TABLE XXXIV.—Best Eight Out of Thirty-One Selected Varieties from 1892.

Names of Mother Varieties.....	Power's		Glyndon		Glyndon		Glyndon		Haynes		Rising's		McKinnon's		Standard Varieties			
	Min.	No. 149	Min.	No. 155	Min.	No. 167	Min.	No. 168	Min.	No. 169	Min.	No. 171	Min.	No. 181	61—Haynes	68—Power's	106—Glyndon	146—Bottom's
Names of New Varieties.....																		
Grown at																		
University Farm, 1895.....	36.2		32.3		30.9	42.7	35.0	37.8	35.0	34.6	21.6	26.3	31.8	35.3				
University Farm, 1896.....	23.3		23.3		22.0	23.0	21.7	25.0	21.7	21.7	24.6	21.4	21.4	25.1				
University Farm, 1897.....	19.9		20.8		21.4	19.9	19.8	24.3	19.8	19.5	20.4	17.4	17.8	21.5				
University Farm, 1898.....	26.5		26.8		26.6	25.0	26.3	26.3	26.3	26.5	23.8	24.0	22.3	22.5				
Northwest Farm, 1898.....	22.3		23.5		20.2	20.3	24.5	22.5	24.5	24.5	23.0	18.8	18.3	19.3				
Northeast Farm, 1898.....	14.0		14.7		16.2	14.7	16.7	19.3	16.7	17.3	23.0	20.7	14.7	19.3				
North Dakota Experiment Station, 1898.....	33.8		35.2		36.5	37.2	38.1	38.4	38.1	35.6	33.5	32.0	32.0	35.3				
Averages.....	25.1		25.5		24.8	20.1	28.0	27.7	27.4	27.8	24.4	22.9	22.6	26.5				

*Averages of only six yields.

TABLE XXIV.—Wheats. Eight Best of Thirty-one Selected from 1893 Mother Plants.

Names of Mother Varieties	Names of New Varieties	Mother Plants in 1892.	Yield of Plant, Grams.	Century Number in 1893.	Yield per acre, Average of six trials.	Grade, Average of six trials.	Weight per Bushel, Average of five trials.	Rust, Average of four trials.	Gluten Test, Average of four trials.				Baker's Sponge Test, Av. of 4 trials					
									Quality.	Per cent. Dry.	Grams of Water held by Each Gram Gluten.	Time	Volume of Rise			cc. Water Absorbed by Each 100 Grams Flour		
													First Rise.	Second Rise.	First Rise.		Second Rise.	Ave. 1 & 2 Rise.	Rise from each Gr. Gluten
Standard Varieties.																		
Power's Fife.....	Minn. No. 149....	108	9.0	601	25.6	91.3	58.8	13	90	13.5	2.13	122	102	1065	788	66.8	54.5	84
Glyndon 818.....	Minn. No. 155....	2540	15.5	3501	25.5	90.0	58.7	11.5	88	13.5	2.04	114	98	1075	663	75.1	70.0	74
Glyndon 753.....	Minn. No. 157....	1277	11.0	4401	25.6	83.6	58.7	11.5	88	13.9	2.08	105	90	1013	688	61.9	49.8	81
Glyndon 811.....	Minn. No. 163....	2201	15.0	4201	27.1	87.3	57.7	11	87	13.8	2.0	113	70	1075	719	65.6	52.	83
Glyndon 761.....	Minn. No. 167....	1701	16.0	42601	26.2	70.0	58.4	10	81	12.7	2.13	105	86	988	713	68.6	58.9	82
Haynes' Blue Stem.....	Minn. No. 169....	476	19.1	6901	28.5	86.3	57.8	6	80	12.5	2.03	120	50	988	688	68.5	58.9	84
Rising's Fife.....	Minn. No. 171....	4944	9.5	13201	26.3	86.1	57.9	10	80	13.1	2.04	103	57	1045	723	71.8	56.9	82
McKendry's Fife.....	Minn. No. 181....	802	13.0	8701	25.9	86.6	57.7	11	91	12.5	2.07	99	62	963	750	71.2	62.0	79
Standard Varieties.																		
Haynes' Blue Stem 51.....	.....	.....	.....	.....	24.6	87.0	57.8	6.2	85	13.4	2.4	114	82	925	731	59.5	54.7	79
Power's Fife.....	.....	.....	.....	.....	23.6	86.0	58.5	12.2	86	14.0	2.12	108	69	938	706	58.9	50.2	81
Bolton's Blue Stem.....	.....	.....	.....	.....	26.5	90.0	58.0	9.5	84	13.2	2.16	126	103	1063	700	69.3	54.9	81

, and a pint, more or less, of seed of each variety was planted at University Farm in 1894, in a small plot, to increase the quantity of seed to a sufficient amount for field variety tests. In 1895 and 1896, the thirty-one new varieties were tested at University Farm in twentieth acre plots. Averages of these two yields were taken, and only the best yielding variety from each original kind was retained. In 1897 and 1898, these eight varieties thus chosen as the best were again tested at University Farm, and in 1898 all of them were tested at the Northeast Station, the North Dakota Station and at the North Dakota Station, and a few of them were grown by the South Dakota and Iowa Experiment Stations. The yields of these varieties for all years and stations are shown in Table XXI. under Minn. Nos. 149, 155, 157, 163, 167, 169, 171, 181, and in Table XXXIV. all the yields which are compared are collected.

Table XXXV. gives the average yields per acre, grades, weights per bushel, ability to resist rust, amount and quality of gluten, results of baker's sponge test of flour, and other facts concerning the eight new wheats. Beside these figures similar facts for comparison are given, concerning the best three wheats the station has collected from the spring wheat growing countries of the world.

It is worthy of mention that the North Dakota Experiment Station has continued the work started there in 1892 and 1893, in making new varieties from the selected and the cross-bred stocks above mentioned. That station has about fifty of the best selected and cross-bred stocks, each of which has been selected from the best mother plant since 1892, 1893 or 1894. A number of the choicest stocks were harvested in bulk in 1898, with a view to increasing the seed in 1899 and making varieties which are to be tested in comparison with the standard wheats found to have yielded best at that station. Those found superior are to be distributed to the farmers of North Dakota. These stocks of wheat that appeared very promising when nearly ripe in 1898, and from several valuable varieties have been branched off from the same stocks, there is good reason to hope that valuable

wheats for the Red River Valley will result. It will be of interest also to compare stocks of wheat from the same mother plant of 1892 selected for several years at the widely separated stations of Minnesota and North Dakota.

BEST EIGHT VARIETIES OF NEW WHEATS AT UNIVERSITY FARM.

In Table XXXVI. are summarized the yields at University Farm only of these best eight new wheats in comparison with the best four out of 200 collected varieties.

It will be observed that some of the new wheats are superior in yield to all of the old wheats, as shown by the averages in Tables XXXIV., XXXV. and XXXVI. In grades, weights per bushel and in ability to resist rust and other characteristics, the new varieties compare favorably with the best old kinds. Some of them are comparatively low in the quantity and the quality of gluten. As a rule, they rank high in milling quality, as shown by the results of the baker's sponge test given in Table XXXV. Some of these wheats give especial promise, and all of them are good varieties. While Minn. No. 163, Minn. No. 169, and Minn. No. 149 show especial promise, others of these eight wheats may prove valuable for at least some portion of the state or of surrounding states. The fact that each of these wheats yields more than Power's Fife and Haynes' Blue Stem, and that only four of them, and they Fife varieties, are exceeded by our best yielding old variety,—Bolton's Blue Stem,—is most encouraging. Here is certainly positive evidence that superior varieties have resulted from this effort at the systematic breeding of wheat by selection.

SEVEN VARIETIES FROM MOTHER PLANTS OF 1892-3-4.

In Table XXXVII. are tabulated the yields of seven wheats which were selected in the nursery during 1892, 1893 and 1894. The best Fife and the best Blue Stem collected prior to 1894, and the best new Fife and the best new Blue Stem variety mentioned in Table XXXIV., are also placed in this table as standards with which to compare these new wheats. None of these

TABLE XXXVII.—Wheats Selected in Nursery in 1892, 1893 and 1894.

Names of Parent Varieties.....	Power's		Glyndon		Mc-Kendry's		Glyndon		Mc-Kissick's		Standard Old Varieties		Standard New Varieties		
	Minn. No.	Fife	Minn. No.	Fife	Minn. No.	Fife	Minn. No.	Fife	Minn. No.	Kissick's Fife	Power's Fife	Bolton's Blue Stem	Glyndon 811	Haynes' Blue Stem	
Names of New Varieties.....	276	66	278	480	283	51	284	477	285	481	286	811	168	287	475
	29.3	18.3	33.0	19.7	33.0	20.3	19.7	27.7	27.7	28.0	22.0	23.3	23.0	23.3	25.0
	18.3	18.3	19.8	14.8	20.3	16.6	14.8	20.7	20.7	19.9	15.7	19.9	19.9	17.4	19.9
	18.3	18.3	19.8	16.6	20.2	17.6	16.6	21.6	21.6	22.6	25.0	26.5	25.0	24.0	26.3
	20.8	20.8	17.9	16.8	17.6	16.8	16.8	22.5	22.5	20.0	18.0	22.3	20.3	18.8	22.5
Averages	21.7	22.6	22.8	17.0	23.1	22.8	20.2	20.4	23.0	24.5	22.0	24.5	24.5	24.5	24.5

seven wheats as yet give promise of especially good yields, though most of them are worthy of further trial.

In Table XXXVIII. are given the summarized facts regarding the yields, grades, milling tests, etc., of these seven new wheats in comparison with several of the stocks of wheat from which they came.

OUT-CROSSED AND IN-CROSSED VARIETIES.

In 1892, many of the strongest plants in the field crop nursery were artificially cross-pollinated. Out-crosses were thus made between plants of different varieties and in-crosses between plants of the same variety. Each of the 101 seeds thus produced in 1892 was planted by itself in the field crop nursery in 1893, and a number was chosen to grow the resulting plant. Through an accident, about two-thirds of the resulting plants were destroyed. Those remaining were harvested separately, and full notes were recorded of each. Only a part of the out-crosses proved to be true crosses. A Blue Stem variety with hairy chaff had been used for the male parents in all the out-crosses, and all the female parents were smooth-chaffed varieties. Where the resulting plants were marked by the hairy chaff of the male parent, the proof of a true cross has been regarded as certain. Where the chaff remained smooth, not showing the character of hairy chaff from the male parent within two years fecundation has been regarded as having resulted from self-pollination, and the varieties have been discarded from further trial, or if especially promising have been classed with the new varieties by selection alone.

From each cross-bred plant grown in 1893, one hundred or more seeds were planted in 1894. The best plant was chosen in each of a number of cases, and from these one or more hundreds of seeds were planted in 1895. After selecting the best plants with which to continue the breeding, and discarding the poorer ones, the remainder of the plants of each stock were harvested in bulk and planted in a small field plot in 1896. From these plots sufficient seed was produced so that in 1897 a twentieth acre plot of each was sown at University Farm. In 1898, these varieties were again

TABLE XXXVIII.—Wheats, Seven Selected Varieties from 1894 Mother Plants.

Minn. No.	Names of Parent Varieties.	Baker's Sponge Test.																							
		Parent Plant in 1892.	Yield of Parent Plant.	Parent Plant in 1893.	Yield of Parent Plant.	Parent Plant in 1894.	Yield of Parent Plant.	Century Number in 1895.	Yield per Acre, Four Trials.	Grade, Av. of Two Trials.	Weight per bush. Av. of Three Trials.	Per Cent. Rust, Av. of Three Trials.	Quality, Two Trials. Per Cent. Dry Gluten.	Grams Water held in One Gr. Gluten.	Time.		Volume of Rise.		Rise from each Gr. Gluten.		Water Absorbed by Flr.				
															1st Rise.	2d Rise.	1st Rise.	2d Rise.	1st Rise.	2d Rise.	1st Rise.	2d Rise.			
276	Power's Fife.....	103	13.8	806	11.8	2222	6.1	23201	21.7	86	55.8	11	92	14.7	2.26	105	74	950	775	60.0	54.5	82			
278	Glyndon #18.....	2476	15.0	3018	14.3	3130	4.9	23601	22.6	86	55.9	10	94	14.2	2.14	105	75	900	850	56.5	47.4	76			
283	Haynes' Blue Stem.....	551	19.3	995	17.2	7621	7.0	27701	22.8	88	56.	8	88	14.0	2.10	110	70	950	862	59.7	49.2	79			
284	McKendry's Fife.....	953		6623	6.3	173	7.3	101	17.0	86	57.	11	88	13.3	2.10	105	78	850	825	57.9	49.3	79			
285	Glyndon 761.....	1731		6650	2.4	311	4.9	1601	23.1	83	55.2	8	95	14.5	2.55		83	875	700	55.2	49.0	79			
286	Glyndon 811.....	2174		6661	10.8	804	9.9	4301	22.8	85	55.6	11	90	12.9	2.15	154	49	925	875	71.0	59.5	81			
287	McKissick's Fife.....	4791		6682	4.2	1379	7.7	7101	20.2	87	56.	12	83	15.7	2.05	136	62	950	750	55.1	48.5	77			
Parent Varieties.																									
51	Haynes' Blue Stem.....								22.8	88	56.2	7	88	14.5	2.04	139	73	1050	738	62.6	51.1	79			
66	Power's Fife.....								20.9	88	56.6	11	92	15.3	2.12	111	90	1225	738	68.2	52.8	81			
168	Glyndon #11.....								16.3	88	56.7	11	85	16.6	2.12	92	101	1000	800	48.2	36.1	83			
476	McKissick's Fife.....								22.5	88	58.	10	95	13.2	2.20	121	87	950	750	64.2	56.8	78			
477	McKendry's Asa. Fife.....								21.0	85	60.	11	95	12.9	1.7	125	65	950	750	65.9	58.1	72			

*1897 crop only. †Average 1897 and 1898 yields only. ‡Average 1896 and 1897 only. §1898 crop only.

TABLE XXXIX.—Yields of Crosses of 1892. Out-crosses vs. In-crosses.

Name of Mother Varieties.....	Out-crosses			In-crosses			Standard and Parent Varieties					
	H. B. S. G. 761	H. B. S. G. 811	H. B. S. G. 811	McKend F. No. 288	Min. No. 292	Min. No. 293	Power's Pile	Power's Pile	Glyndon 811	Haynes' Blue Stem	Kistling's Pile	McKendry's Assinabola Pile
Name of New Varieties.....												
Grown at												
University Farm, 1897.....	20.4	15.5	19.3	14.4	17.9	18.0	17.4	19.9	19.9	24.3	20.9	18.2
University Farm, 1898.....	26.0	27.6	27.0	31.3	32.0	21.3	21.0	26.5	25.0	26.3	26.6	23.8
N. W. Farm, 1898.....	17.6	16.8	20.0	21.3	17.7	20.0	18.8	22.3	20.3	22.5	.....	.....
Averages.....	21.3	20.0	22.1	22.3	22.5	19.8	20.1	22.9	21.7	24.4	.....	.....

tested at University Farm and at Northwest Farm. In Table XXXIX. the yields of three out-crosses and three in-crosses are tabulated. With them are placed the best parent Fife variety, Minn. No. 66, and the best two new Fife varieties, Nos. 149 and 163, also the best new Blue Stem variety, No. 169.

It will be observed that some of the in-crosses and also some of the out-crosses have made very creditable yields in comparison with our best varieties. These results indicate that useful varieties of wheat may be originated from single carefully selected mother plants one generation from the cross. It by no means follows that it is the wiser course to start at once new varieties, rather than to continue the selection of newly crossed stocks to a single best plant out of one or more hundreds for each of several generations before using a single plant as a mother of a new variety, or to first grow the cross-bred wheats in the field for a few years, and then subject them to extensive nursery selection before increasing into a variety. It must be said, however, that while these new out-crossed wheats are known to be true crosses, they have shown very little tendency to vary or revert to types other than the type of the 1894 mother plant, of the second generation after the cross, from which they originated.

In only one of the in-crossed wheats have we evidence of there being a true cross. Minn. No. 292, Risting's Fife X Risting's Fife, (Minn. No. 476 X Minn. No. 476), is a much lighter colored wheat than the parent variety, and presumably the changed color is a variation resulting from the cross between two plants of the same variety.

It is not to be expected that even under a most rigid selection of plants in the nursery that all resulting cross-bred varieties will prove valuable when subjected to field trials. That a majority of the six thus far tried give promise of being among our best wheats gives a basis for the hope that by systematic cross-breeding followed by rigid selection varieties may be originated which will prove superior not only to the best parent wheats collected, but superior also to the best wheats originated by selection alone. Experiments mentioned elsewhere demonstrate that greater varia-

tion is produced by crossing than occurs in wheat permitted to self-fertilize.

Rigid selection of these cross-bred stocks through a series of years will doubtless result in finding those plants which are adapted to becoming the progenitors of heavy yielding varieties of good quality. This selection includes (1) the choice of the best yielding plants bearing good grain in the nursery, (2) the varieties yielding best in the variety field trials, and (3) those proving to have high quality in the milling tests. In Table XL. are given the summarized facts relative to yield, grade, milling, and baking qualities, etc., of these six cross-bred wheats.

NEW WHEATS COMPARED WITH PARENT VARIETIES.

In Tables XLI. to L., inclusive, the yields of several new wheats are tabulated beside the yields of the varieties from which they came. Some of the new varieties do not appear here because the parent variety has been discarded from the variety tests.

In Table XLI., Minn. No. 161 is shown to yield slightly less than its parent variety. This new variety was originated from a

**TABLE XLI.—Minn. No. 161 Compared with its Parent Variety.
Haynes' Blue Stem.**

Grown at	Varieties.	Haynes' Blue Stem.	Minn. No. 161.
University Farm, 1893.....		21.6	27.2
University Farm, 1896.....		24.6	25.0
University Farm, 1897.....		20.4	18.9
University Farm, 1898.....		23.3	18.2
Average.....		22.5	22.3
Loss.....			0.2

single plant of Haynes' Blue Stem grown in 1892, in a similar manner as the eight varieties given in Table XXXIV. were origin-

ed. It has been discarded from further trial because of its poor yielding qualities.

In Table XLII., another variety, Minn. No. 169, originated at the same time and from the same parent variety as Minn. No. 161, mentioned above, but from a different mother plant, is compared with the parent variety. In columns two and three are given yields at University Farm, Northeast Farm, South Dakota Experiment Station and at the Iowa Experiment Station, with the

TABLE XLII.—Minn. No. 169 Compared with its Parent, Haynes' Blue Stem.

Grown at \ Variety	Haynes' Blue Stem—Minn. No. 61	Minnesota No. 169	Haynes' Blue Stem—Minn. No. 61	Minnesota No. 169
University Farm, 1895.....	21.6	37.8	21.6	37.8
University Farm, 1896.....	24.8	25.0	24.8	25.0
University Farm, 1897.....	20.4	24.3	20.4	24.3
University Farm, 1898.....	23.3	26.3	23.3	26.3
E. Farm, 1898.....	28.0	19.8		
S. Dakota, 1898.....	20.2	14.1		
S. Dakota, 1898.....	33.5	38.4		
Iowa, 1898.....	8.8	12.5		
Averages.....	21.9	24.7	22.5	28.3
Gain.....		2.8		5.8

TABLE XLIII.—Minn. No. 149, Compared with Its Parent Variety, Power's Fife.

Grown at \ Variety	Power's Fife No. 66.	Minnesota No. 149.	Power's Fife No. 66.	Minnesota No. 149.
University Farm, 1895.....	26.3	36.2	26.3	36.2
University Farm, 1896.....	21.4	28.3	21.4	28.3
South Dakota, 1896.....	22.5	22.7		
University Farm, 1897.....	17.4	19.9	17.4	19.9
University Farm, 1898.....	24.0	26.5	24.0	26.5
E. Farm, 1898.....	18.8	22.3		
E. Farm, 1898.....	20.7	14.0		
South Dakota, 1898.....	17.4	15.4		
South Dakota, 1898.....	32.0	33.8		
Iowa, 1898.....	7.0	7.5		
Averages.....	20.7	22.1	22.3	26.5
Gain.....		1.4		4.2

average for eight yields. Here the increased yield of the new wheat over its parent is 2.8 bushels per acre. In columns four and

five, four yields are given at University Farm only. Here the average shows an increased yield in the new wheat of 5.8 bushels per acre over its parent.

This is the most promising of all the newly originated wheats. Being a Blue Stem variety, it will doubtless become popular in the southern two-thirds of the state.

In Table XLIII., in like manner Minn. No. 149 is compared with No. 66, Power's Fife, the variety from which it was originated. Averaging the eight yields, at the several farms, the increased productiveness of the new variety over the parent is shown to be 1.4 bushels per acre, and averaging the four yields at University Farm, the increased yield is 4.2 bushels.

In Table XLIV., Minn. No. 477, McKendry's Fife, is compared with three of its progeny. Only the two yields for 1897 and 1898 at University Farm are available for the comparison.

TABLE XLIV.—Minn. Nos. 181, 284 and 288 Compared with their Parent Variety, McKendry's Fife.

Grown at	Variety.	McKendry's Fife.			
		Foundation Stock.	Parent Plant, Selected 1892.	Parent Plant, Selected 1892-1894.	Parent Plant, In-cross Selected 1892-1894.
		Minn. No. 477	Minn. No. 181	Minn. No. 284	Minn. No. 288
University Farm, 1897...		18.2	19.5	14.8	14.4
University Farm, 1898...		28.8	26.5	16.6	31.3
Averages.....		21.0	23.0	15.7	22.8
Gain or Loss.....			+2.0	-5.3	+1.8

Minn. No. 181 was originated from a mother plant grown in the nursery in 1892. It shows an increased yield of two bushels per acre.

Minn. No. 284 was selected in the nursery in 1892, 1893 and 1894, being multiplied from the single mother plant grown in 1892. Here we have the remarkable decrease in yield of 5.3 bushels per acre.

Minn. No. 288 is from a flower pollinated with pollen from a plant of the same variety in 1892. The cross-bred plant was

own in 1893, and from it in 1894, 100 plants were grown. From among these the best plant was chosen as the mother plant of this variety. The average increased yield here is shown to be 1.8 bushels per acre.

TABLE XLV.—Minn. No. 276 Compared With Its Parent Variety, Power's Fife.

.....	Power's Fife	Sel. Mother Plant 1894
.....	66	276
Grown at		
.....	17.4	18.3
.....	24.0	18.3
.....	18.8	20.8
Averages.....	20.1	19.1
Difference.....		1.0

In Table XLV., Minn. No. 66, Power's Fife, is compared with Minn. No. 276, which was originated from the Power's Fife nursery. It was selected in 1892, 1893 and 1894, the best plant being retained in 1894 for a mother plant. A decrease in yield of one bushel per acre is shown.

TABLE XLVI.—Minn. No. 283 Compared with its Parent Variety, Haynes' Blue Stem.

.....	Haynes' Blue Stem.	Selected from 1894 Mother Plant,
.....	51	283
Grown at		
.....	20.4	20.3
.....	20.3	20.2
Averages.....	20.4	20.3
Difference.....		0.1

In Table XLVI., Minn. No. 283 is compared with its parent variety, Minn. No. 51, Haynes' Blue Stem. This new variety was subjected to nursery selection in 1892-4, inclusive, originating from a best plant grown in 1894. The decreased yield here shown is one bushel per acre.

In Table XLVII., Minn. No. 476, Risting's Fife, is compared with three varieties which have sprung from it. Minn. No. 171 was originated by selecting the best plant of Risting's Fife in the

TABLE XLVII.—Minn. Nos. 171, 292 and 293 Compared with the Parent Variety, Risting's Fife.

Grown at	Variety.	Risting's Fife.			
		Foundation	Selected from	In-cross of	In-cross of
		Stock.	1892 Mother Plant.	1892, 1894 Mother Plant.	1892, 1894 Mother Plant.
		Minn. No. 476	Minn. No. 171	Minn. No. 292	Minn. No. 293
Univ. Farm, 1897.....		20.9	19.8	17.9	18.0
Univ. Farm, 1898.....		26.6	26.3	32.0	21.3
Averages.....		23.8	23.1	25.0	19.7
Gain or Loss.....			-.7	+1.2	-4.1

nursery in 1892 for a mother plant. A decreased average yield of seven-tenths of a bushel per acre is here shown.

Minn. No. 292 is the result of an in-cross made in 1892 between two plants of Risting's Fife. The plant resulting from this cross was grown in 1893, and from it 100 plants were grown in

TABLE XLVIII.—Minn. No. 287 Compared With Its Parent Variety McKissick's Fife.

Grown at	Variety	McKissick's Fife	
		Foundation	Selected from
		Stock	1892-1894 Mother Plant
		Minn. No. 475	Minn. No. 287
University Farm, 1897.....		20.4	15.7
University Farm, 1898.....		24.6	25.0
Averages.....		22.5	20.4
Loss.....			2.1

1894. From the best plant of this 100, some 900 plants were grown in 1895, and of these the best 300 were selected and the grain from them planted as a variety in 1896. This variety is

oubtless the result of a true in-cross, since the berry is of a much lighter color than the parent wheat. The averages show an increased yield of 1.2 bushels per acre.

Minn. No. 293 had its origin in the same manner as 292, excepting that its 1893 cross-bred parent plant originated from crossing two other Risting's Fife plants than those used in producing the parent plant of No. 292. A marked decrease in yield of 4.1 bushels per acre, as compared with the parent variety, is shown in the averages. In this case there is no satisfactory evidence that this variety is the result of a true cross.

In Table XLVIII., Minn. No. 475, McKissick's Fife, is compared with Minn. No. 287, which was originated from a single plant of McKissick's Fife in 1894. This mother plant was from nursery stock which had been selected to the best plant in 1892 and 1893. A decreased yield of 2.1 bushels per acre is here shown.

TABLE XLIX.—Minn. No. 163 Compared with the Parent Variety, Glyndon 811.

Variety.....	Glyndon 811. Minn. No. 168.	Minn. No. 163.
Grown at		
University Farm, 1895.....	42.2	42.7
University Farm, 1896.....	19.0	23.0
University Farm, 1897.....	16.3	19.9
Averages.....	25.8	28.5
Gain.....		+2.7

In Table XLIX., the promising new wheat, Minn. No. 163, compared with its parent variety, Minn. No. 168, Glyndon 811. This parent variety was one of the wheats grown at Glyndon, Minn., in 1891. It has every appearance of a Fife wheat, and probably was originally collected in this country, though its name was lost by fire. The average of three yields shows an increase of 2.7 bushels per acre. Arrangements were made with numerous farmers and seedsmen to grow this wheat in 1899 and sell it for seed to the farmers of the state.

TABLE L.—New Varieties Compared with their Parents: +Gains; —Losses.

Minn. Nos. of Par- ents	Minn. Nos. of New Varieties	Minn. No. 161	Minn. No. 169	Minn. No. 283	Minn. No. 149	Minn. No. 276	Minn. No. 171	Minn. No. 292	Minn. No. 293	Minn. No. 287	Minn. No. 163	Minn. No. 181	Minn. No. 284	Minn. No. 288
	No. of Trials Averaged.....	4	8	2	10	3	2	2	2	2	3	2	2	2
	Parents													
51	Haynes' Blue Stem.....	-2	+2.8	- 0.1	+1.4	-1.0								
66	Power's Fife.....													
476	Risting's Fife.....						-7	+1.2	-4.1	-2.1				
475	McKissick's Fife.....													
168	Glyndon 811.....										+2.7	+2.0	-5.3	+1.8
477	McKendry's Fife.....													
	Gains at University Farm Only.....		+5.8		+4.2									

In Table L., is given a summary of the increase or decrease of the new varieties over the parent kinds as shown in Tables XLI. to XLIX. Out of the thirteen wheats thus compared six give promise of increased yield, while with seven a decrease of yields has resulted. The average increased yield of the six improved wheats is 1.98 bushels per acre. The average decreased yield of the poorer new wheats is 1.92 bushels. Minn. No. 293 shows the most marked variation in yield, and that a retrograde variation. Minn. No. 169 shows the most pronounced increase in yield. This table gives the most positive evidence that marked variation occurs, both towards better and towards poorer yields. *Where variation occurs improvements may be effected.* A comprehensive detailed plan of operations diligently and accurately carried out for a long series of years cannot fail to very materially increase the productiveness and the quality of wheat or any other crop.

METHODS OF DISSEMINATING NEW VARIETIES.

The work of originating new varieties of seeds after plans mentioned above brings out a new element in seed distribution. There is needed a method of retaining the identity of varieties which resemble their parent varieties in appearance, differing only in yield and quality of grain. Since their identity cannot be retained by botanical description, it must be done historically. The seller or purchaser of the seeds of a given variety needs a means of tracing the seed back to its source.

In sending out kinds of plants which have not been broken up into varieties or sub-varieties similar in appearance, as timothy or orchard grass, the seeds may quite properly be sent out under their specific names. With our new Fife and Blue Stem wheats, or with most of our newly-originated varieties of bromus or timothy, this would lead to a confusion of names and stocks of the seed. The original variety might easily be passed off for the new and better yielding kinds.

In case of open fertilized plants like corn, timothy, brome grass or millet, small samples sent from the station would often be

planted beside fields of common stocks of the same kind of plants. This would result in cross-breeding, and the improved characters of the new varieties would be modified by the more prepotent race characters of the common kinds, and the improved characters would thus be nearly destroyed.

The plan we have devised for the distribution of our promising varieties is outlined as follows: Several men in each county, preferably graduates of the School of Agriculture, are encouraged to become growers of certified seeds of field crops. Men are chosen who have good land, and who rotate their crops in a manner to give the best possible conditions for seed growing. Those who keep live stock that they may grow a goodly proportion of crops which enrich the farm and clean the land of weeds, who are business-like in their dealings, and who have the confidence of their neighbors, are desirable seed growers.

Arrangements are made with these farmers to grow seeds of varieties which the state experiment station has tested until it is assured that they will succeed in the counties to which they are sent. It seems wise to send out comparatively few varieties, and to do all the preliminary testing at University Farm and at the sub-station farms. The seeds are to be sold in some quantity, usually in bushel or bag lots, that each seed grower or farmer may grow them in fields rather than in small patches, and the station desires that modest but remunerative prices be asked and given for these certified seeds.

It is believed that under this plan each new variety will be more rapidly multiplied, if it proves valuable, than if the station were to break the first lot of seeds up into small packages and send them out free of cost. Paying a reasonable price for a new variety of grain, thus well vouched for, would cause the new owner to take an interest in it. A small profit, say twenty-five cents per bushel on seed wheat, would repay the seed grower for his extra work in growing, caring for and cleaning seeds for sale to the other farmers in the county. The farmers securing these new varieties from our seed growers could make a small margin of profit by selling these certified seeds to still other neighbors. It seems practicable

the station to supply blank certificates with descriptions, which growers could sign and give with each quantity of seed sold, thus "certifying" it to be the variety described on the certificate. To avoid errors, seed growers could occasionally submit specimens of the plants and seeds to the experiment station for comparison with the original sample. Those purchasing direct from the experiment station might be required to send samples to the station to be used as a record of the fact of their having received the variety intended for them. Seed firms within the state should be aided to procure stocks of the new varieties that they might also propagate them for sale. We have no other agency so efficiently organized for distributing useful seeds, and their full co-operation is desirable. Their facilities for advertising a new stock of seeds are superior to any other medium, and the financial interest of the seed companies would cause them to procure these well-tested varieties and advertise them for sale. Seedsmen and nurserymen properly argue that each firm cannot afford to test all the new varieties. Instead of so many experimental grounds, the experiment station, with its better equipment, can do the larger part of the work. Likewise the station can best originate or secure and thoroughly test, and finally certify to the value of seeds of field crops, and thus insure good stocks for the farmers and a more satisfactory business to the seed merchant.

TABLE LI.—Minn. No. 168 Compared with Best Fife and Blue Stem Wheats.

Name of Variety.	University Farm, 1895	University Farm, 1896	University Farm, 1897	University Farm, 1898	North Dakota, 1898	South Dakota, 1898	N. E. Farm, 1898	Iowa, 1898	Total	Average
6 Power's Fife.....	26.3	21.4	17.4	24.0	32.0	17.4	20.7	7.0	166.2	20.8
6 Bolton's Blue Stem.....	35.3	25.1	21.5	22.5	35.3	17.3	19.3	6.3	182.6	22.8
8 A New Variety.....	42.7	23.0	19.9	25.0	37.2	15.4	14.7	8.0	185.9	23.2
6 Power's Fife.....	26.3	21.4	17.4	24.0	{ Yields at University Farm only. }				89.1	22.8
6 Bolton's Blue Stem.....	35.3	25.1	21.5	22.5					104.4	26.1
8 A New Variety.....	42.7	23.0	19.9	25.0					110.6	27.7

A blank certificate is used by the station in selling seeds to its list of recommended farmers who have been chosen to assist in the introduction of new varieties. It is designed to supply these men with a number of these blank certificates, which they in like manner may fill out to go with the wheat to farmers to whom they in turn sell the seed of varieties supplied to them by the station. The circular briefly states whatever is known of the origin, the method of breeding, the general character of the plant, the comparative yield, the grade, the milling qualities and other facts which may be known about the variety. A circular prepared to accompany Minn. No. 163 wheat, a few hundred bushels of which is being distributed for planting in 1899, contains the Table LI., comparing the yields of that wheat with our best collected Fife and best collected Blue Stem wheats. The following form of blank certificate is also attached to this circular, and is properly filled out for those purchasing this wheat:

CERTIFICATE OF MINNESOTA NO. 163 WHEAT.

I hereby certify that the seed wheat sold by me and marked order No. on this. day of the month of in the year to , County, Minnesota, was originated and raised by the State Experiment Station, and is being disseminated under the name of Minnesota No. 163, as described in the circular attached hereto; and that this sample has been kept free from admixture with other varieties of wheat.

.....
Agriculturist.

St. Anthony Park, Minn.

....., 1899.

SOME BOTANICAL CHARACTERISTICS OF WHEAT.

There are some features of the botany of wheat in relation to farming which are worthy of attention. The farmer needs a knowledge of the roots, the leaves and the kernel of the wheat, that he may understand preparing the land for this cereal, and better know how to sow, harvest and preserve the crop. The wheat breeder also needs to know the general anatomy and physiology of wheat, and he especially needs a knowledge of the structure and functions of the floral organs.

BOTANICAL RELATIONS OF WHEAT.

The relation of wheat to other classes of plants will not be entered upon extensively here. Mr. Warren W. Pendergast, when student, adapted from Haeckel's "The True Grasses" Table LII, showing the thirteen tribes of the great grass family. From the same book he also adapted Table LIII, showing (1) the six sub-tribes of the tribe Hordeæ; (2) the five genera of the sub-tribe Triticæ; (3) the two sections of the genus, *Triticum*; (4) the three species of the section, *Sitopyrus*; (5) the three races of *Tr. sativum* and (6) the four principal sub-races of the race, *Tr. sativum tenax*.

This elaborate classification of the genus *Triticum* is necessitated by the numerous forms into which wheat has become differentiated, in part, since coming under the influence of man.

The species first mentioned, *Triticum monococcum*, is, as the name implies, one seeded, and is so different from the common varieties of wheat, *Tr. sativum*, that the two have not been successfully cross-fertilized.

The third species, *Tr. Polonicum*, is evidently not so distant in relationship, and an occasional fertile flower may be secured

TABLE LII.—Classification of the Grass Family, showing relation of Wheat to other Tribes.

GRAMINEÆ.	
Spikelets 1 Flowered.	Maydeæ—[Corn-Teosinte.] (Tribes.)
	Andropogonææ—[Suga Cane—Sorghum.] Zysetæ.
Spikelets Many Flowered.	Tristegineæ. Paniceæ—[Millet—Hungarian Grass.] Oryzæ—[Indian Rice—Rice.] Phalaridææ—[Canary and Sweet Vernal Grass.] Agrostidææ—[Timothy—Red Top] Avenææ—[Oats.] Festucææ—[Blue Grass—Bromus—Orchard-Grass-Fescues.] Chloridææ—[Grama and Buffalo Grass.] Hordeææ—[Wheat—Barley—Rye—English Rye-Grass.] Bambusææ—[Bamboo.]

TABLE LIII.—Classification of Wheat.

HORDEÆ..... (Tribe)	
Nardeæ. (Sub-tribe)	
Loliceæ. [Rye Grass.]	Agropyrum. (Genus) [Quack Grass.]
Leptureæ.	Haynaldia.
Triticeæ.....	Secale. [Rye.]
Elymææ. [Barley. Wild Rye.]	Triticum..... Heterantheridium.
Parinacæ.	Ægilops. (Section) { Sitopyrus. Tr. sativum..... Tr. polonicum. [Polish Wheat.] Tr. sat. tenax..... Tr. sat. Spelta. (Race) [Rice spelt.] Tr. sat. Dicoecum. Tr. sat. turgidum [Eng. Wheat, Egyptian or Miracle Wheat.] Tr. sat. durum.

cross-pollenating it with *Tr. sativum*, our common species. Our experiments so far have been directed to making crosses between the widely differing varieties, and even there the variation is considerable and seems to be more often backward or downward than toward useful forms. Since the Polish wheats have not shown an adaptability to our climate and soils the chance of securing useful crosses between them and our best wheats is very remote.

The races of spelt wheat, *Tr. sat. spelta*, have not shown an ability to yield well either at University Farm or at Northeast Farm, where Mr. Pendergast tried one of them, thinking it might prove useful on light soils, such as these wheats are grown on in north-Spain. At University Farm it has been much worse affected by rust than our common Blue Stem and Fife varieties.

The sub-races of the sub-species or race, *Tr. sat. tenax*, are not so well adapted to our conditions.

Our common bearded and smooth wheats, both winter and spring varieties, belong to the race first named in the last column of the chart, *Tr. sat. vulgare*. Haeckel remarks that the characters of these four sub-races overlap. Each of these sub-races is broken up into many varieties, some of which are probably the result of crosses between the sub-races. Common wheat, *Tr. sat. vulgare*, has been known since ancient times, grains having been discovered in the Egyptian Pyramids, and the assumption is safe that this sub-race has been very much modified by man.

Tr. sat. compactum, "Dwarf wheat," or "Hedgebog wheat," Haeckel says, was found in the ruins of the old lake dwellings of Lake Neuchâten.

Neither of the sub-races, *Tr. sat. turgidum*, English wheat, nor *Tr. sat. durum*, Flint wheat, have made any progress toward general cultivation in the middle Northwest. Mr. M. A. Carlton, special agent of the Department of Agriculture, Washington, D. C., has expressed the hope that *durum* wheats might be a good source of rust-resistant blood to use in crosses with the common wheats in some sections of this country.

Our experiments have demonstrated the superiority for our conditions of the Blue Stem and Fife wheats, which are varieties of

Tr. sat vulgare. These varieties yield the most wheat of the best quality, and are the most rust resistant of all which we have tried. Doubtless this power of rust resistance is the main reason why these wheats have proven themselves best on our experimental farms, and among our farmers. The rust is an ever-present disease, and varieties which have rusted badly have always given poor yields and wheat of poor quality. Blue Stem is more rust resistant at University Farm than is Fife wheat, and no doubt the better yields here and among the farmers of Minnesota are in large part due to this characteristic. While other varieties are being used in the effort to find or make better kinds, our variety testing and breeding is centering more closely in these two wheats. In many respects these wheats are similar, yet in their relationship to the rust they are quite distant, as is clearly shown by the great variation of their cross-bred progeny, and also by the fact that Blue Stem has hairy chaff, while the chaff of the Fife is smooth.

An era of producing new varieties of wheat by crossing has evidently set in, one man, Mr. Wm. Farrar, having sent us five new cross-bred wheats at one time from Australia. The selection or "roguing" to which we subject newly received varieties, to reduce them to type changes them somewhat, and a description which might publish would not apply to the stock of wheat in the hands of other parties. No attempt can be made in this bulletin to publish descriptions of our many wheats, and their value if published would not be great.

The nomenclature of wheat in our grain markets is comparatively easy when we have little else than Fife and Blue Stem, but with the multiplication of varieties the confusion of names will be great. Botanists and teachers often give an undue proportion of their attention to the botanical characters, and too little to the intrinsic value or money-earning power of varieties. Some of our new varieties have no botanical distinguishing marks by which they can be separated from the class of wheat to which they belong, but they yield more wheat per acre, and are much more valuable to the farmer. With records, we must keep them true to the

nal, as live stock breeders must record their animals, and in giving them give certificates of genuineness.

While the experiment station is disposed to investigate all new varieties and races of wheat, and to give garden or even field trials to new wheats of promise, we have learned by wide experience that our work should mainly be directed to making better wheats of the best varieties already in hand, and to devote considerable attention to a new wheat only as it is shown to be very promising of usefulness. There is ample opportunity among the wheats which have been successfully grown to make crosses, some of which are even radical for practical breeding. The attempt has not been made to produce botanical wonders, but to add to the yield of the acre of wheat. Now that a fairly good method of improving practical varieties has been devised and successfully used, it seems wise to put more time on those theoretical questions the solution of which will enable us to still further perfect the methods of breeding this grain from which is made the "staff of life."

Many questions of interest from the standpoint of systematic botany are constantly arising where so many notes are yearly accumulating on numerous selected and cross-bred stocks of wheat. Some of the questions of greatest interest are the questions which yearly arise regarding heredity, variation, and the practical theories of plant and animal breeding.

WHEAT IS USEFUL IN STUDYING PLANT AND ANIMAL BREEDING.

Hugo de Vries, of the University of Amsterdam, has recently pointed out that most of the theories for correct practice in breeding animals, as well as plants, can best be worked out with plants, in preference to animals, because they may be used in such large numbers. With animals, the small numbers produced at a birth and the great expense of keeping all under similar conditions and of making records, makes their use unsatisfactory and so costly as to be almost prohibitive.

The wheat plant is one of the very best of all plants for the solution of many of these problems. We have been able to devise a

thoroughly feasible plan of dealing with the individual whereby each plant has practically an equal chance with each other plant. The notes of yield of seeds per plant, of quality of grain, of strength of straw, of rust resistance, of height, of character of spikes, etc., are easily and accurately recorded. If need be, the seeds may be kept for a number of years, and from seeds thus preserved plants may be grown in comparison with progeny which have been modified by breeding or environment. Of great importance in this connection is the fact that wheat is nearly close-fertilized. Another important consideration is the fact that cross-bred stocks of this close-fertilized plant may be selected to a uniform type in a few years, the time required depending upon the variable nature of the particular cross. We now have in store seeds of unselected stocks, of stocks selected for shorter and longer periods to single mother plants, of cross-bred wheats from mating plants of different degrees of relationship, and of different types of cross-bred wheats not as yet selected to uniform types, and those selected until they are partially uniform, others where uniformity has been secured by being longer subjected to selection to a type. These, with new wheats the station is constantly acquiring, are highly valued for use in many experiments, under way or soon to be started, in studying numerous questions in breeding.

THE WHEAT PLANT.

In Minnesota the plants of those varieties of spring wheat commonly sown reach a height of from thirty-five to forty inches. In some cases on moist rich land, the height mentioned is exceeded while in dry seasons on poor land, the wheat sometimes ripens at a height of two feet or even less. The modern self-binder can successfully cut and bind into bundles straw which does not stand two feet high, but for best results it is desirable to have the wheat stand thirty to forty inches high. Wheat much higher than forty inches is likely to lodge in wet seasons and on rich, moist soils, and in breeding wheat only moderate height with great stiffness of straw, is sought. A goodly proportion of leaves is necessary, that the wheat may be well supplied with these organs, which serve both as

lungs and stomach to the plant. But a disposition to produce an unnecessary proportion of leaves is undesirable. The plant should center its food material in its seeds, and not lay it aside in other organs of less value.

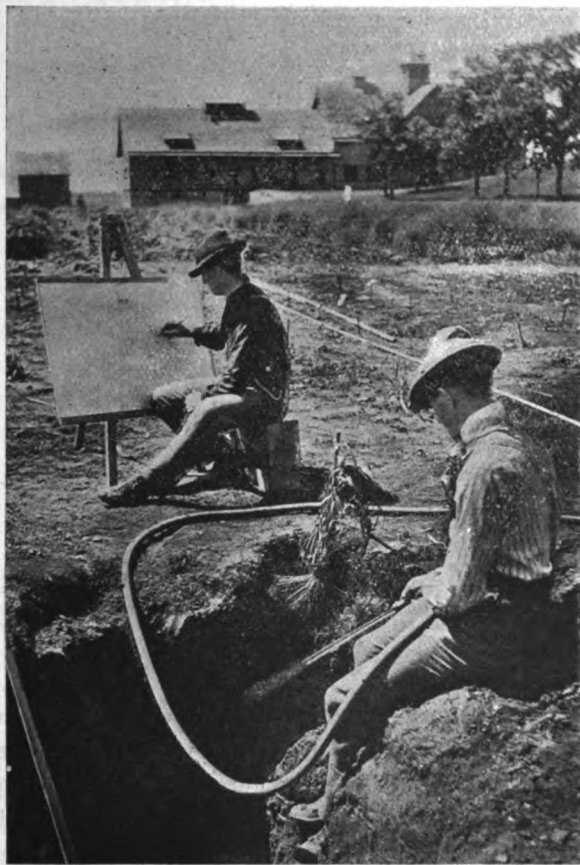


Fig. 250. Washing out Wheat Roots and Making Drawings.

A well developed system of roots is a necessity to the plant. There is no direct way by which the breeder can select for this quality. But by choosing vigorous yielders, the law of correlation of parts aids to select individuals with all the essential organs well

developed. While the breeder may pay no attention to the roots the farmer in preparing the soil for this crop needs to know the habits of the plant in sending its roots throughout the soil. The method of stooling, also, is of interest in connection with the soil with the time and thickness of sowing the seed, and especially in connection with the harrowing or otherwise cultivating the soil after the grain has germinated.

THE ROOTS AND STEMS OF WHEAT.

In 1898, a dozen wheat plants were grown in a plat of land where water from a hydrant could be used to wash out the roots that

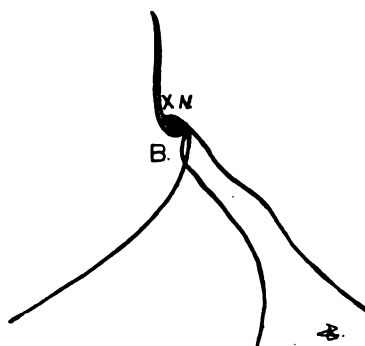
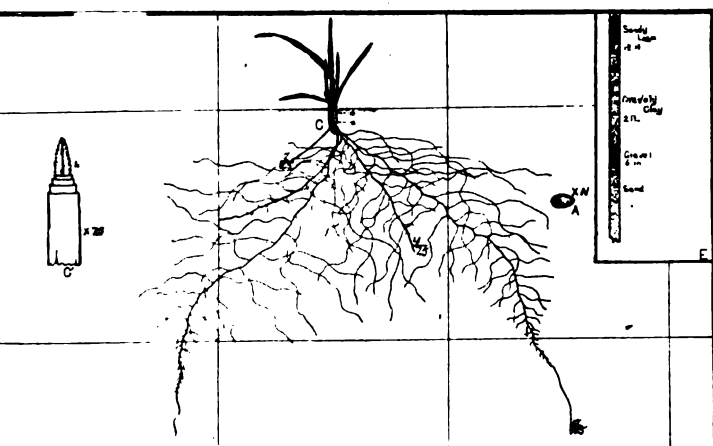


Fig. 251. The entire wheat plant five days old, natural size. The roots are more than twice as long as the stem. No matter in what position the germ of the seed lies, the stem end at once seeks an upward direction and the roots go outward and downward.

drawings might be made showing the root development at different stages of growth. Individual plants were grown several feet apart, and at stated intervals a plant was washed out and a drawing made of its root system. Messrs. Carl S. Scofield and Coates P. Bull, students, did the work on these plants, the latter doing most of the drawing. Each root springing from the culms was carefully followed out and measured, records being taken of its depth, the distance of the point from the plant and the general direction or curvature of the root. The various stem-roots were thus faithfully grouped on the charts so as to represent a view of them as though one were looking at them in a horizontal direction.

the soil removed and the roots left in position where they grew. These drawings are shown in Figs. 251-9. A diagram showing the character of the soil in which these plants were grown after washing out is given at E in Fig. 252.

Figure 251 shows the young plantlet of spring wheat at five weeks old. The direction of the three roots is more nearly downward than usual, as the seed was planted somewhat late. In cooler weather they take a more nearly horizontal position. Close in-



252. A—The kernel of wheat. B—Diagram of the soil in which wheat plants were grown for washing out roots. C—Wheat plant at 23 days old, longest roots four or five times as long as the plant is tall. These squares represent feet, the longest root is 19.5 inches long and about 16 inches deep. c—The joint of the stem dissected out from c at a-b; b—the miniature spike.

section of a germinating kernel of wheat will show that the stem and the first whorl of roots, usually three in number, have their origin in the chit or germ. See C, 15, and C, s and r, 16, Plate V., page 412. Until somewhat further developed than the plant shown in Fig. 251, the kernel is the sole source of food for the young plant. Not until it has green leaves in the sunlight does the young plant have green chlorophyll cells with which to digest plant food from the soil and by combining it with water and carbonic acid of the air elaborate substances which the plant tis-

sues can use. The reason for using well matured, plump, heavy seeds, is that such a kernel has more food for the young plant, and the food is of good quality. As shown in Fig. 16, Plate XXV, the chit or minute plantlet is but a small portion of the seed. The main body of the kernel is the starchy and glutenous content. During germination these substances are changed into soluble forms and passing through the juices of the plant are used in developing the cell walls and the protoplasmic cell contents of the small roots and leaves and the tiny axis or stem.

THE ROOTS GROW RAPIDLY.

The wheat plant passes rapidly from the germinating stage, and

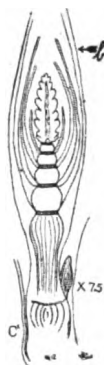
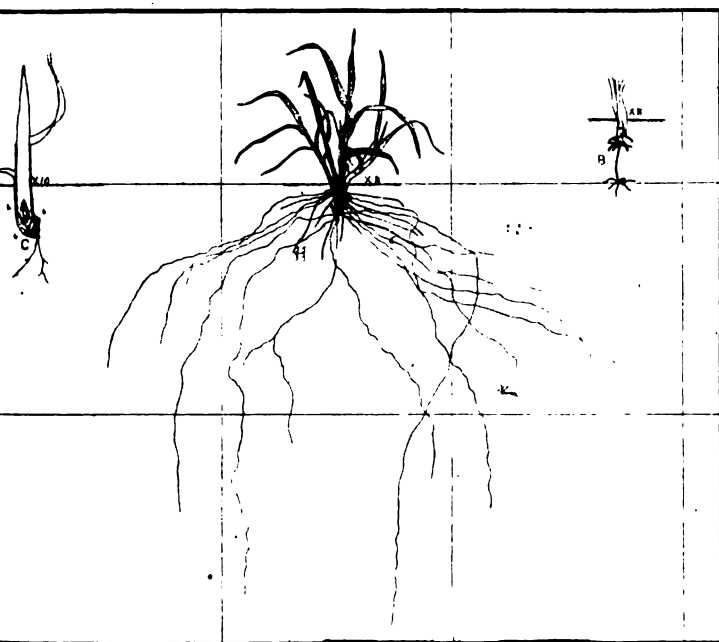


Fig. 253. A diagrammatic section through the stem of wheat about 25 days after planting, magnified $7\frac{1}{2}$ times, as from *a* to *b* in C, Fig. 252. The first bud designed to form a tiller is just starting. One blade starts from each joint.

with favorable conditions soon has green leaves absorbing the sun's rays and a spreading mat of roots absorbing water and plant food from the soil. In Fig. 252 a plant twenty-three days after planting is shown. The blades are only five inches high, while the earliest roots which sprang from the chit are twenty inches long. The roots are long and numerous, and in comparison with the area the leaves expose to the sun they present a large area of root surface to the soil. Upon dissecting out the stem from among the mass of leaf sheaths, a very small point is found extending from the lower joint at *a* to *b* in C. This miniature primary culm

shown enlarged several diameters at C. Even at this stage the
 re is discernable, as at *h* in C.

Fig. 253 shows the branching culm still more elaborately figured
 diagram. The attachment of the leaves at the nodes will be
 served, also the fact that the internodes are as yet short, having
 nodes or joints very close together. The first secondary
 m or tiller at *x* indicates that "stooling" has already begun.



254. Wheat plant 43 days old. Blades eight inches high and roots two feet. Branching roots are not shown. B—the kernel with its three or four roots; culms and roots branching out half way from the kernel to the surface of the soil, where roots and leaves spring from the stem or rhizome. C—The branching culm. *b*, *b*—buds which will become tillers. *h*—miniature spike.

In Fig. 254 a plant 43 days old is shown. Here three or four
 orls of roots have developed, and the culm has produced several
 ls or tillers. No attempt is made to show the many branching
 ts, only the roots originating from joints of the culm being
 wn.

In Fig. 255 is shown a plant 63 days old; the roots emanating from the culms and seed, in all enumerating about fifty; also, one of the dozen or more culms. At this stage the wheat was about

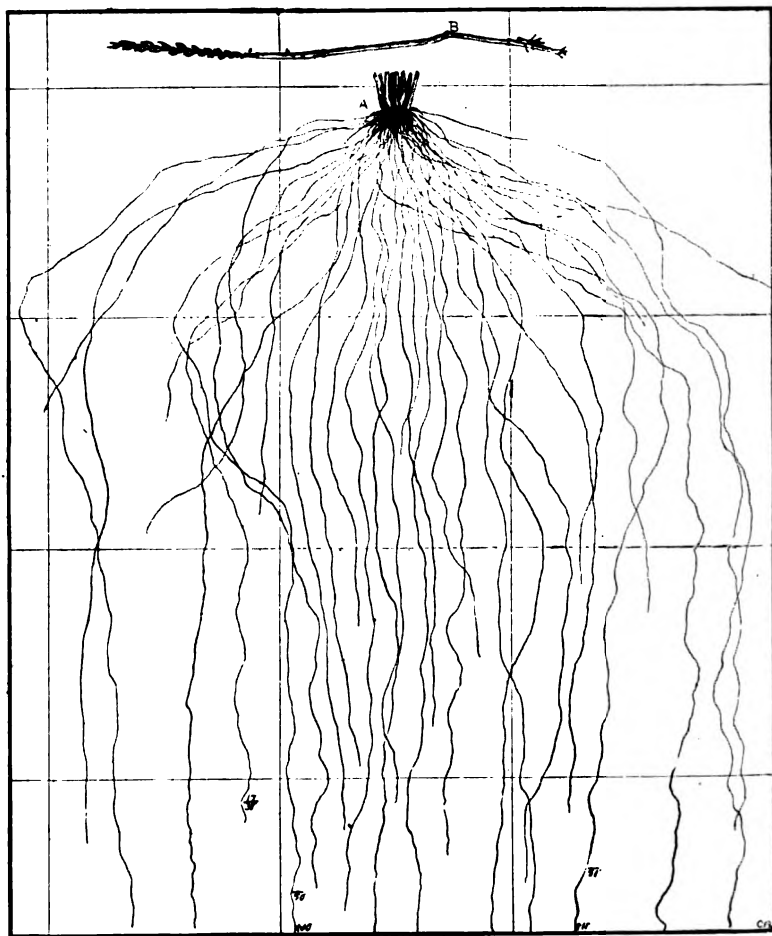
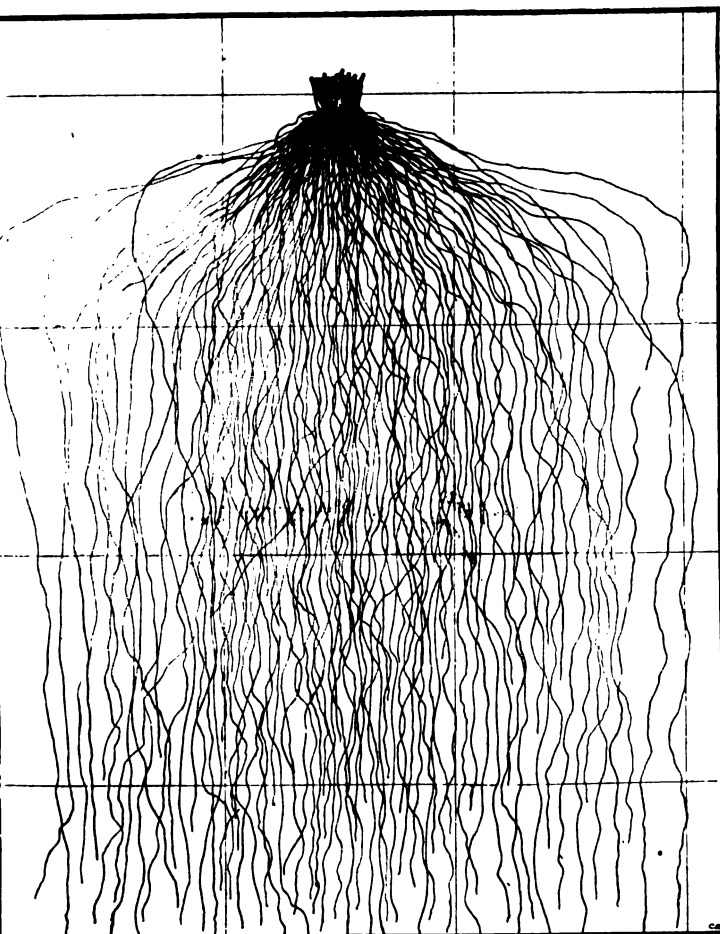


Fig. 255. A—"Crown" and stem-roots of a plant 63 days old, branching roots not shown. (Figures near the bottom of the plate show spread and depth of the respective roots.) B—Culm nearly ready for the head to appear from leaf sheath.

two feet high and ready to head out, and some of the roots had penetrated to the depth of more than four feet.

In Fig. 256, the roots are shown from a plant which was near-maturity. Here there were sixteen culms and nearly one hun-



256.. Crown and stem roots of a mature wheat plant, from one seed. There are about 100 stem roots, each of which had for some distance on an average about eight branch roots to the inch, making a wonderful mat of roots in the soil.

d roots springing from the culms. Where crowded in the field each seed gives rise to only a few culms. The roots had not gone much deeper than those shown in Fig. 255, owing in part to the

coarse character of the soil, though many of them went deeper than the three feet eight inches shown by the drawing.

THE PLAN OF THE ROOT SYSTEM.

There is order in the attachment of the roots to the seed and culms and in the manner of branching. Three roots start from the chit at the same time that the stem starts upward. These are

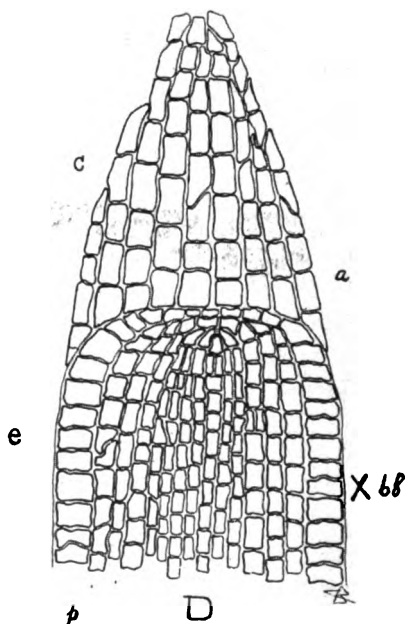


Fig. 257. Point of the wheat root. c—the root cap; e—periderm; a—apical area; p—corticle.

a temporary set of roots which usually die before the plant is fully grown; in case of winter wheat they were all found dead in the spring in several varieties which were examined. As the culms develop they send out roots from the bases of their leaves. Presumably the root buds spring out in whorls from around the nodes under the bases of the leaves, as is the case in Indian corn. See bulletin 5, page 10. Those roots which spring out first when the plants are as yet young are small in diameter and much

unched. In the cool autumn or in cool weather early in spring the first roots go out more nearly in a horizontal direction than in warm weather, as in early autumn or late spring planting. When these roots are several inches long, branches begin to show, and they soon have many branches. Each culm sends out from a few joints at its lower end a number of roots for its separate support, and each culm soon depends largely upon its own roots. Those first coming out reach the greatest length, while some of the uppermost roots start out so late as to not have time to grow long, though these later roots springing from higher up on the culm usually have a greater diameter than the threadlike roots which first started. The roots throw out many branches in the upper eighteen inches of earth, and these branches again branch. Those roots which penetrate deeper go nearly straight downward and have few or no branches below eighteen or twenty-four inches. Since the branches, as well as the stem roots, radiate outward from the plant, there are few roots immediately beneath a plant which stands alone, while in the field this space is occupied by the roots of neighboring plants. Since there are about eight branch roots to the inch for eighteen to twenty inches down each culm root and each of these branches is from one-tenth of an inch to twenty-four inches in length, it can be seen what an immense number of roots each plant has.

THE ROOT HAIRS AND THE ROOT CAP.

Mere branching into innumerable thread-like branch roots does not give the roots sufficient contact with the soil, and each root and branch root is covered with hairs which extend among the fine particles of soil. These root hairs have been appropriately called "feeding cells" or "sucking cells," and through their thin walls the plant gets the larger part of its water and plant food. Beginning near the tip of the root, these hairs are very short. Proceeding upward toward the stem, they are longer. Within a few inches the hairs which are observed are shriveled, showing that there is a short life near the end of the root on which active hairs are born, but that each hair has a short period of activity. Back of this the

outer covering of the root has become hard and the root serves merely as an avenue for the passage of water and plant food taken in by the active zones bearing fresh hairs. Here branching roots, in case of the stem roots, take the place of the hairs, and they in turn bear hairs on zones near their freshly developed points.



Fig. 258. A small section of a wheat root showing the root hairs, enlarged two diameters.

In Fig. 259 is a cross-section of a root showing three root hairs. These hairs are not distributed evenly along the root, they being thin in places, and at other points very thick, the density of the hairs doubtless depending much upon the local conditions of moisture and plant food. Roughly stated, there are about fifty hairs to the millimeter in length of root.

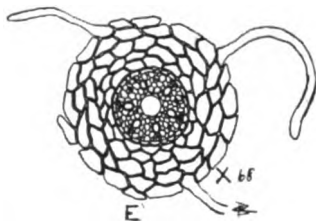


Fig. 259. Cross-section of a wheat root near the tip showing three root hairs and the manner of their development.

The power roots have of penetrating hard earth is surprising. Fig. 257 shows a cross-section through the point of a root. The wedge-shaped cap, C, is pushed in between the soil particles, and by the subdivision and growth of the cells in the middle of the root at *a* the diameter of the root is enlarged and the point is pressed still farther forward. Many of the roots were found distorted in pass-

through the subsoil just below the furrow-slice where repeated loading of the plow team and the pressure of the plow had made the earth compact.

These drawings show what a power this crop has of spreading into the soil far and deep for its food. It was not practical to show the immense number of branch roots on Figs. 255 and 256, since they were so numerous that the paper would have been black throughout the center of the drawing.

THE BRANCHING OF THE CULM.

The culm or stem of the wheat plant is made up of a series of hollow cylindrical internodes joined together by means of solid joints or nodes.

In starting from the seed the stem soon begins to branch. The first leaves which are sent up seem to be a temporary set of organs designed to quickly reach above the soil, that the plant may be supplied with green cells in the sunlight. These leaves form what appears to be the primary shoot of the plant, and spring from the culm near the seed. They are found to be dead in the spring, along with the germ whorl of roots, in case of several varieties of winter wheat. At the same point where these first leaves arise from the culm, apparently a rhizome, branches off from the primary stem. This rhizome has an internode quite unlike all the other lower internodes, not even covered by the sheath of a leaf, and extending about half way to the surface of the soil. In case the seed is planted two inches deep this rhizome is about one inch long. See B in Fig. 254. At the top of this internode a joint bears a leaf, and a few other joints follow at very short intervals, each having a bud in the axil of its leaf. At C, Fig. 254, is shown a longitudinal section of one of these buds after it has grown into a tiller or stool. The minute spike is shown at *h*, and two branches appear at *b*, *b*. Roots also have made their appearance. Each branch may subdivide, and plants from single kernels of wheat have been known to develop several dozens of culms. These branches only occur from the few lower nodes, but the branches

may again produce branches from their lower nodes. When the wheat is in the stooling stage, at several inches high, the base of the stems appears compact and bulbous, especially if cool, moist weather and a rich soil have favored the development of numerous strong tillers.

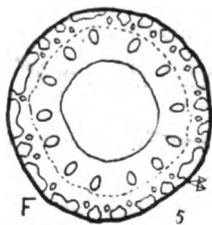


Fig. 260. Cross-section of internode—the stem between the joints.

By observing Fig. 254, it will be seen that the bulbous crown of the wheat is near the surface. The roots branch off from the several culms, not at the point where the seed was placed, but much nearer the surface. When planted deeply the wheat plant lifts the bottoms of its stems nearly or quite to the surface by means

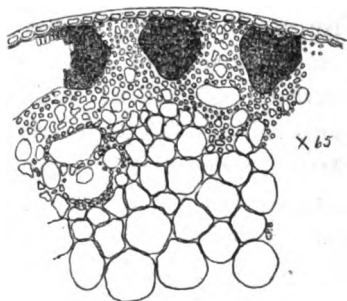


Fig. 261. A portion of a cross-section of the stem of wheat, in detail.

of the long internode of its rhizome, which develops shorter or longer according to the depth to which the seed has been planted. See Fig. 254 B. It will be seen that wheat plants thus set in the surface of the soil, with their roots extending outward at an angle of less than forty-five degrees from horizontal, can easily be injured by harrowing the wheat field after the plants are up, and es-

cially after they have "stooled out." This certainly is what has occurred in a number of experiments where dragging the growing wheat has lessened the yield of grain.

A partially developed culm is shown in 255 at B. Fig. 260 shows a cross-section of an internode, and Fig. 261 a much magnified portion of the same.

When the tiny shoot is sent out of the germinating seed it is mostly a mass of leaves. It rises above the soil, where the leaves expand into the air to receive a large number of the rays of the sun. These rays, by the aid of the green chlorophyll cells, are changed from rays of light to active force, and then again changed into the plant into latent energy and stored up in such chemical compounds as sugar, starch, fat, cellulose and gluten. During the first few weeks the stems are very short, branching organs, whose chief functions at this time seem to be to produce leaves and roots. Not until the field is covered with a thick mat of blades nearly a foot high do the stems change their habit and extend upward. The plant up to this time has been expending its energies on the production of a wide expanse of leaf and in sending innumerable roots far and wide into the soil. The working parts of the plant having been developed, it sends up its shoots very rapidly, and when the culms have reached their full height the work of growing the fruit for the harvest is begun in earnest.

In the crowded field, however, the branches from branches rarely develop, as the field becomes crowded so that the leaves of these stools have no room in which to develop. The plant is particular to those branches which start earliest, and is loath to start new ones. If a tiller cannot quickly send out its own leaves for air and sunshine, and soon reach into the soil and there compete with other roots for food, it must give up the race and leave the field to those that started early. If the conditions are favorable, many will succeed in getting enough roots started to enable them to compete in the effort to run up culms, and the stand of wheat will be good; while if the conditions are unfavorable, few culms will result and the wheat will stand thinly on the field.

When the plant has an abundance of blades and roots, the culms

begin to lengthen. This is accomplished by the lengthening first of the joints near the ground, as shown at B in Fig. 255. The upper culms, b and a, soon follow, however, and the ear of wheat rises above the leaves. As the culm lengthens, the blades from the upper joints also develop and become active leaves of the plant; while those which rose from near the roots and did service earlier, pass their period of activity and wither, leaving the work to the upper leaves, which are better situated to gather sunlight and food from the air. The leaf sheath completely surrounds the stem, and the edges overlap each other.

The development of the spike from the first tiny rudiments of an ear, as shown at *h* in C, Fig. 252, to the mature head of wheat, may be followed with interest. All that is needed is a sharp pointed knife and patient work in dissecting away the leaves at the various stages of growth of the plant. A small magnifying glass for ordinary work and a dissecting and compound microscope for reaching the greater minutia, are very useful for successful studies in these processes.

THE SPIKE AND THE FLOWER.

The spike of common wheat is made up of a central crooked stem called a "rachis." This rachis is jointed, and at every joint it bears a group of flowers called a "spikelet." See 2, Plate XXV. The rachis bends in the opposite direction at each joint, and thus the spikelets are arranged alternately in two rows on opposite sides of the rachis. This gives a nearly rounded appearance to the spike. The spikes are usually slightly smaller at the ends because there the spikelets are not so well developed or are farther apart. In some wheats, however, as in the club varieties, the internodes of the rachis are much shorter towards the top of the spike, resulting in the spikelets being much closer together and in the spike being broad at the top, or "club" shaped. This characteristic is sometimes shown by cross-bred wheats where neither parent had this characteristic, and may be the result of atavism or striking back to remote ancestors.

In Fig. 262 are shown the spikes of three varieties of wheats.

18 is a spike of Blue Stem, 19 a spike of Red Fife wheat, and 20 is a spike of Preston, one of the best new wheats we have yet



18

20

19

Fig. 262. 18 Blue Stem, 19 Red Fife, 20 Preston.

ceived. It is a strongly bearded wheat which originated from a cross made by Dr. Wm. Saunders, of the Canadian experimental station, Ottawa, Can. The Blue Stem is awnless, but its white chaff is covered with a coat of fine velvety hairs. Red Fife, also, is awnless, and its white chaff is free from hairs.

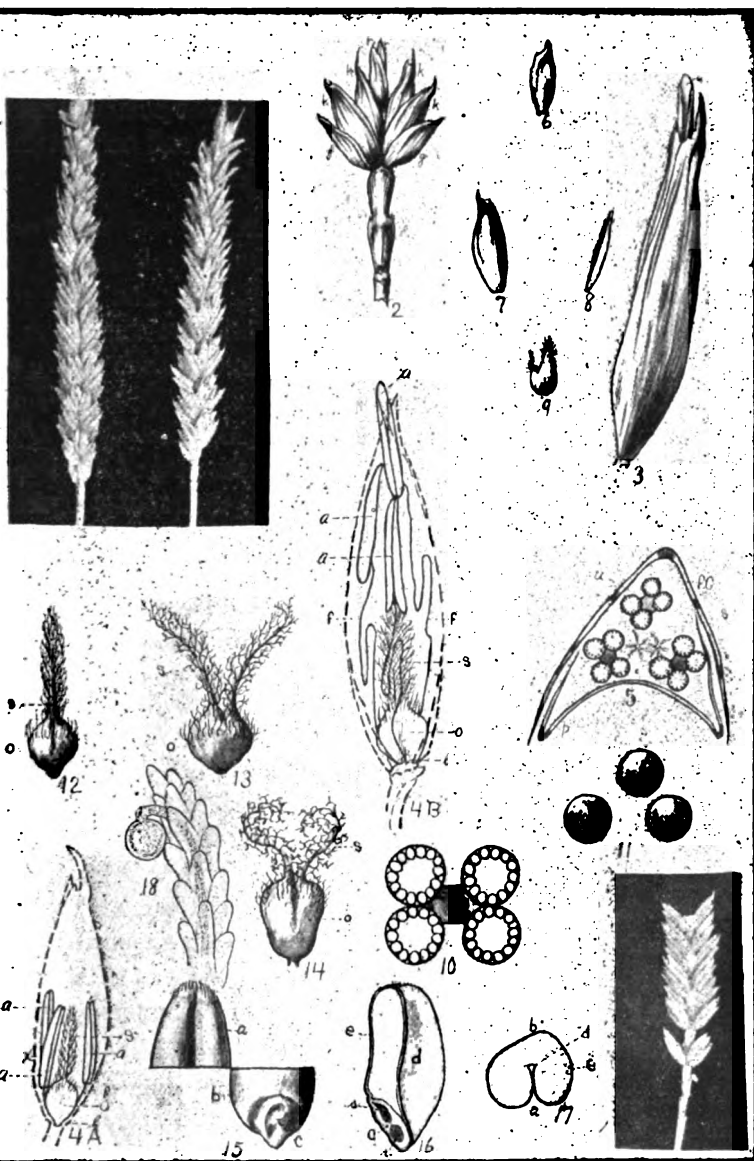
The spikelet branches off at the angle of the central stem or rachis

of the spike. Its short stem, called rachilla, bears two or more florets. A spikelet is shown at 2, Plate XXV. If the conditions are favorable, each spikelet may produce several mature seeds, but very frequently only two or three reach maturity, thus materially reducing the yield of grain. Below the lower floret the rachilla bears two flowerless glumes, *f* and *g*, 2, also 7, Plate XXV, which closely resemble the flowering glumes. Above these the several flowering glumes are arranged alternately on the rachilla. In Plate XXV, 2, *k, k, k, k*, represent flowers bearing seeds and *r, r*, represent rudimentary flowers.

The Floret is by far the most interesting part of the wheat plant. The flowering glume is the outer and larger of the two portions of the chaff which enclose the floral organs, and later the seed, while the smaller or inner portion of chaff is called the palea. The palea is on the ventral, or creased side of the kernel and its two sides are folded inside the keel-shaped flowering glume, and are shorter and thinner than the latter. The floret is shown at 3, Plate XXV, the flowering glume at 6 and the palea at 8. A third portion of the floral envelope is shown at 9, four times its natural size. This small organ is called the lodicule. It is at the base of the flowering glume and palea, and is so placed between them that by swelling it pushes them apart. It is believed that this little organ absorbs water and swells up when the flower is ready to be fertilized.

-
- Plate XXV, shows the spikes, flowers and seed of wheat.
 The smaller spike is Fife and at its left is shown a Blue Stem spike. In the lower right hand corner is a spike from which small late flowers have been removed preparatory to crossing.
 At 2, spikelet, natural size, with a few joints of the rachis; *f* and *g* are flowerless glumes; *k*, florets bearing seeds; *r*, rudimentary florets.
 3, a single flower closed just after flowering, X4.
 4A, longitudinal diagram before flowering, X3; anthers marked *a*; ovary, *o*; stigma, *s*; filament, *f*.
 4B, diagram of floret just after flowering, X4, showing how anthers are held within the envelope.
 5, transverse diagrammatic section, or floral plan, as is made by cutting across 4A at X, X7; *fg*, flowering glume; *p*, palea; *a*, anthers; *s*, stigma.
 6, flowerless glume; 7, flowering glume; 8, palea; all natural size.
 9, lodicule, X4, shown also at L in 4B.
 10, cross-section of anther, X30; showing the pollen sacs and the central mass of tissue to which they are attached.
 11, pollen grains, round and smooth, 55 micro millimeters in diameter.
 12, ovary and stigma just prior to flowering; 13, at the time of flowering; and 14, shortly after flowering.
 15, 16 and 17, the mature seed; *a*, the ventral side; *b*, the dorsal side; *c*, the germ or chit; *s*, the stem end of the germs; *r*, the root end; *e*, outer layers or bran; *d*, the incurved surface of bran on the ventral side of the seed. The white portions of 16 and 17 are the floury interior consisting of cells containing the gluten and starch from which white flour is made.

Plate XXV. The Reproductive Organs of Wheat.



and thus assists in opening the chaff, as will be seen later in connection with the flowers shown in Plate XXVI. Its position is shown at *l* in 4B, Plate XXV. When not filled with water it is a flat, almost leaf-shaped organ, but when full of water it is rounded out like a minute sack. Being so near the point of attachment of the two parts of the chaff, it needs to swell only slightly to press their outer points some distance apart.

The male and female organs of the immature flower are closely packed within the lower part of the compartment enclosed by the chaff, as shown in the diagram 4A, Plate XXV. The three stamens are shown at *a*; the filaments which bear the stamens at *f*; the stigma at *s*, and the ovary at *o*. The floral plan is shown by the cross-section at 5, where the flowering glume, *f*, *g*, and the palea *p*, are folded about the three anthers, *a*, and the stigma *s*. 4B shows a longitudinal section of the floret at the time of flowering. The anthers, *a*, have been pushed upward by the rapid elongation of the filaments at *f*; and because the glume and palea did not fully open, the anthers were caught and the filaments were bent upon themselves in their endeavor to lift the anthers out of the floret. The stigma remains folded up as shown in 12, Plate XXV, while the flower is yet immature; and it expands, as in 13, when the floret is in the fertilizing stage, as in 4B.

When the anthers are being pushed upward by the filaments they break open, as in 2, 3, 4, 12, 13 and 14, in Plate XXVI, and allow pollen grains to fall on the stigma of the same floret, and often scatter other pollen grains outside the floret.

A cross-section of the anthers is shown at 10, Plate XXV. It is made up of four round sacs, the two pairs being supported by a central mass of tissue, as shown in the engraving. The inner wall of each sack is lined with a single layer of the minute globular pollen grains. The pollen grains are shown at 11, Plate XXV.

At the flowering time the stigma is spread out, as in 13, Plate XXV, is moist and in a condition to receive the pollen grains and cause it to germinate. In 18, Plate XXV., a pollen grain is shown germinating and sending its pollen tube into a branch of

stigma. The protoplasmic contents of the pollen grain in this manner grows downward through the stigma and style, and passes to the ovary, *o*, 13. In the center of the ovary is the minute female cell, called the "ovule." The pollen tube reaches this, when it and the ovule coalesce, completing the fertilization of the seed. The stigma, having done its duty, soon becomes shriveled, as shown in 14, Plate XXV.; while the ovary begins a rapid development and soon reaches the full size of the mature berry.

HOW THE FLOWERS AND ANTHERS OPEN.

There is a general belief that since wheat does not often cross in nature its floral covering does not open. Having observed that some of the anthers escape, and that their filaments are caught between the glume and palea at a point below their center, I was decided to make observations through the day, and if necessary at night, to see when and how much the floral envelope opens. It was found that the flowers open very early in the morning, just as day is dawning. A flower was sketched at intervals during its opening and closing, and these sketches, together with the exact time of making each, are presented in Plate XXVI, at 1 to 8 inclusive. The flower began opening at forty minutes past four, and closed at eighteen minutes past five. Other flowers observed required from thirty-five to fifty-five minutes to open and close again, or, generally speaking, three-fourths of an hour for the entire operation.

By observing the progressive stages in figures 1 to 8, it will be seen that the anthers move upward as the flower opens, and before the flower is closed many of them have been pushed upward and have fallen out, the upper end now hanging downward. Not all, however, are raised sufficiently high to escape. In 9, Plate XXVI, a diagrammatic section shows the flower as closed, only one anther having escaped; and in 10 none of the anthers succeeded in falling out of the enveloping chaff.

The figures in the lower column, 11 to 16, inclusive, show the development of the pollen sacs. When the flower begins to open, as in

1, the anther is not open, as in 11, as a rule. But as the opening of the flower proceeds, as in 2, the anther splits open, as in 12 and 13. The anthers in a flower nearly open, as in 4, are ready to pass out of the floral envelope, and at this time they are freely shedding their pollen into the floret on the stigma. When the anther drops over and hangs downward, as in 4 to 8, inclusive; or when it is re-inclosed in the envelope, as in 9 and 10, it soon splits open through-

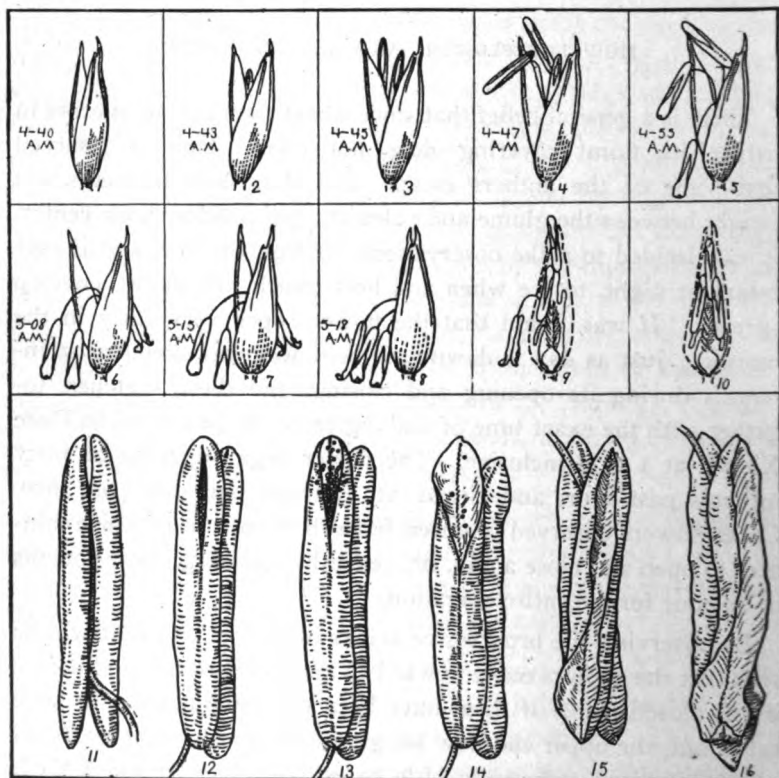


Plate XXVI. The Opening of Wheat Flowers and Anthers.

Note.—The opening of the wheat flower at early dawn is shown in 1 to 5, inclusive; and its closing in 6 to 8, inclusive; the time of making each sketch being given on the plate. In 9 only one anther passes out of the envelope and in 10 none escaped before the flower closed. In 11 is shown the anther with its attachment to the filament, in 12 to 16, inclusive, are shown the progressive changes in the opening of the pollen sacs and in 15 and 16 they are shown as having fallen out from the flower, thus inverting their position and allowing the remaining pollen to fall out.

its entire length, and becomes shriveled and brown, as in 15 and 16. A large amount of the pollen is lost by anthers which fall out of the envelope after they drop over and hang downward. The fact that the glumes and palea spread so widely, and that much pollen is scattered outside the florets, makes it probable that there is more crossing in wheat than has been generally supposed. An experiment is in progress to test this question. Plants of some of the varieties which have been successfully crossed were grown side by side in rows three inches apart last season. Seeds of these are to be planted and the proportion of cross-bred plants which result will be determined. General observation in the field indicates that these varieties, though mixed, rarely cross. Blue Stem and Fife wheats, for example, of which we have made numerous crosses, are often found mixed in the field, but none of the variable forms produced by artificial crosses have been observed.

THE KERNEL OF WHEAT.

Wheat has the first place among the farinaceous grains as food for man, because of that quality of its gluten which allows the dough to expand the dough into a beautiful sponge, soft, palatable, and snowy white. Having that proportion of nitrogenous and carbonaceous food elements best suited to man's needs, its use makes food rations too poor in nitrogen and too bulky. And when used freely by persons who eat too much meat it makes their ration less rich and more healthful. The more abundant the cheaper this cereal can be grown the better for all classes of consumers.

The work of raising wheat, of breeding better varieties, and of improving the ripened grain all centers around the berry, which should be brought to the complex processes of milling in a perfect form that good flour may finally be the result. The kernel of wheat, though small and apparently simple, has a wonderful history, and its structure is of interest. Several of the parts of the grain are shown in Plate XXV at 15, 16 and 17. See notes ac-

companying description. Fig. 264 shows a highly magnified section of a grain of wheat through the bran and including a few layers of the farinaceous cells inside the covering of bran.

The bran is composed of several layers. Two layers, a, b, and c, are made up of strong cells overlapping in such a way as to make a tough integument covering the berry of wheat. A third fairly strong layer, c, lies inside these outer ones and against the inner, colored layer of the bran. This latter is called the "aleurone layer, since its nearly cubical cells are partly filled with aleurone grains. These cells lie against the floury interior of the kernel.

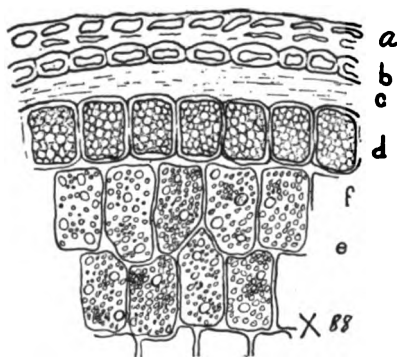


Fig. 264. Highly magnified section of portion of grain of wheat, as at X in Fig. 263; a, b, and c, outer coats or bran of the grain; d, aleurone layer; e and f, floury interior starch cells of the grain.



Fig. 263. Transverse section of a grain of wheat.

They contain fermenting substances which during the germination of the seed act on the floury cells making their contents soluble and ready for the use of the germinating plantlet.

Though this layer of cells is rich in materials suitable for human food, the effort in the roller mill is to crumble the floury cells off the inside of the bran, leaving the aleurone cells attached to the tough part of the bran. These aleurone cells have masses of colored materials in them which give to the flour a darker color than is desired by present market fashions, and it is believed that these aleurone cells contain ferments which increase the dangers of spoiling in flour exported to foreign markets.

The floury cells, *f* and *e* in Fig. 264, fill up the mass of the kernel of wheat. Each floury cell has a thin wall, and its contents are principally starch granules—very small, nearly globular masses of definite composition (C_6, H_{10}, O_5)—and masses of glutenous compounds, together with small amounts of fats and ash. The proportion of gluten is slightly larger in those cells which are nearest the aleurone layer, while those farthest from the bran and the middle of the kernel are somewhat more starchy, as is shown by the whiter appearance.

The Amount and Quality of Gluten Important.—The percentages of gluten in wheats have much to do with the food and market values of flour made from the different varieties. But the quality of the gluten has even a greater influence on the prices of wheat than does the quantity. In quantity the gluten in the varieties of wheat tested by this station ranged from 17.9 per cent. to 28.8 per cent. The quality of this gluten, expressed in a scale of 100 points, ranged from 35 to 87½. In a general way wheats are grouped by millers into two classes. Those with weak gluten are called "soft" wheats, and those with strong gluten are called "hard" wheats. These terms are used in a somewhat confusing manner. Some classes of wheats which are hard when crushed, but break between the teeth, have gluten of very poor quality, though they may have a high percentage in quantity, and will not make flour which will rise into a light loaf. This wheat is not wanted by millers at any price, since even a small percentage of it in a baking mixture will seriously injure the quality of the flour.

The gluten of wheat is composed of several nitrogenous compounds, mainly gliadin and glutenin. When these are present in the right proportions to each other they form a tough, elastic mass within the dough or sponge, which is stretched by the gas developed in the interstices by the yeast germs. Prof. Harry W. Snyder, Minnesota Bulletin 54, pp. 37-38, says: "An excessive amount of gliadin and a small amount of glutenin make a soft, sticky dough. An excessive amount of glutenin and a small amount of gliadin prevent the gas from being retained and the bread from becoming light. * * * The gliadin, by binding

together the particles of flour, enables the dough to retain the gas

* * * The glutenin 'serves as a nucleus to which the gliadin adheres,' and it prevents the dough from becoming soft and sticky." Prof. Snyder found that a good sample of Red Fife wheat contained about 14 per cent. of protein compounds, 11.3 per cent. of which were gliadin and glutenin; the proportion of the two latter being about six of the gliadin to four of the glutenin. This wheat has very good gluten. Dough from Fife wheat flour rises high, is not "runny," and the gluten has the enduring power to rise again and again with successive "working down" of the dough. Prof. Snyder found a slightly greater proportion of gliadin to glutenin in Blue Stem wheat than in Fife wheat. Blue Stem proves in baking tests to be nearly or quite equal to Red Fife wheat if neither have ever been wet or otherwise injured.

Since good quality of gluten, together with at least fair quantity, is of so much importance, most careful attention must be paid to selecting and breeding varieties from which good flour may be made and to so harvesting and storing the grain that the gluten is perfectly preserved.

THE MODERN PROCESS OF MILLING WHEAT.

The making of wheat flour has been wonderfully revolutionized during the last quarter of a century. The burr mill has given way to the complex roller mill, with its graded product of flour, bran, shorts, and screenings. The great Pillsbury A mill has a capacity of 10,000 barrels of flour daily, requiring several trains to bring the wheat and remove the flour. The process in one of these mills is bewildering in its complexity. The grain is cleaned to remove the weed seeds and other foreign substances. It is scoured to remove the hairs from the outer end and even the chaff is rubbed off. It is washed in water if infested with stinking smut. And if the bran is dry and brittle, the grain is moistened with steam or water to toughen the bran before the grain passes between the rolls so that the bran will not be crumbled up with the flour. The miller seeks only the interior of the kernel without

by foreign matter whatever, and his machinery and processes are arranged for that purpose. If it were possible for the farmers to produce only plump kernels, well fattened up, full of starch, and with bran tough, smooth, and uninjured by exposure to the weather, the miller would have a less difficult task and could produce a still better flour. The farmers do not use the care nor develop the skill in raising the wheat that the millers do in manufacturing it into flour and there are some lessons farmers need to learn from the mills. They need to realize that the miller must have a good bran. He views the outside of the kernel. In purchasing he rarely even bites it in two that he may see the character of the inside. In purchasing a given variety of wheat he makes the price according to the plumpness and the color and general appearance of the bran. He wants the bran bright in color. If wheat has been alternately exposed to rain and sun in uncapped shocks, or has lain wet in the bin, the bran will have lost its tough texture and will crumble, small particles going with the flour through the finest silk sieves. This discolors the flour and reduces its keeping qualities. Besides, the rising power of the dough is injured by becoming wet or by heating in stack or bin.

METHODS OF BREEDING WHEAT.

Securing foundation stocks is the first requisite in preparing to improve wheat, since more depends upon the parent variety than upon the breeding. While much may be accomplished by scientific effort, it is too much to expect or hope that more can be thus accomplished in a few decades than has been done in many centuries of care by past generations of wheat growers. In previous pages are given the plans employed in collecting and testing in the field, in the mill, and in the bake-room varieties of wheat secured from many parts of the world. Since no one variety of wheat is adapted to giving the best results in all parts of the state, the best wheats are being tested on the several experimental farms, that the best old and best new wheats for each portion of the state may be known and distributed in the respective districts. With the increase of good varieties there is an adaptation of kind to special conditions. Sandy soils will probably be best suited to certain wheats bred to resist drouth and a less liberal supply of plant food. Those farmers who have rich or moist lands and who keep much live stock to enrich their fields, will be especially partial to those varieties which have good ability for standing erect. With University Farm, Northwest Farm, and Northeast Farm, the Experiment Station is equipped to compare varieties of wheats for various conditions of soil and climate. Several tests at each farm are necessary, that reliable averages may be made for comparing the wheats. The varieties now in hand are an excellent basis for improvement by breeding.

Practical experience with nearly fifty newly originated varieties as well as with some hundreds of collected wheats, clearly demonstrates that it is economy to give all wheats a thorough trial a

the experiment farms before distributing any to the farmers. Tri-
 by the farmers with small samples, sent free, are in the aggre-
 te expensive to the farmers and not very satisfactory. Our new
 eats are sent out only after thorough trial as to yield and mill-
 g quality, and the chances are that each new kind distributed will
 ove valuable, in at least portions of the state. The station is
 iginating many varieties, but only a few of the very best are
 ing distributed. So far about three per cent. of the new wheats
 e especially promising, and these are being increased for sale.
 nce some of the new wheats are proving better than any of the
 d wheats, only new kinds are now being multiplied for distribu-
 on.

That a superior new wheat introduced into the state may
 ove of great value, we have only to realize the importance
 the northwest of the introduction of Red Fife or of Blue Stem
 eat. Little is known as to the history of how they came to be
 roduced, but what was done by individuals or by chance may
 duplicated through systematic effort with still other superior
 varieties.

NOTE.—A new variety can be rapidly multiplied. In 1890 this station dis-
 posed, mostly in bag lots, a carload of superior Fife wheat, donated for that
 pose by Mr. C. A. Pillsbury, of the Pillsbury-Washburn Milling Company of
 Minneapolis. In some townships this wheat had been so multiplied in several
 ars that little else was grown.

A farmer at Park River, Walsh county, N. Dak., secured a small package of
 ite Russian oats. In a decade these oats had been so multiplied that nearly the
 ire crop of the county was from this stock of seed.

Prof. W. A. Henry, director of the Wisconsin Experiment Station, in the first
 ual Report of that station, pp. 17-21, gives the history of the introduction
 anshury barley into America. In a recent letter to the writers, Prof. Henry
 ly states the facts thus: "This barley was carried from the mountains of
 ntchooria to the King's Garden, Germany, and from there by a German-Ameri-
 isiting Germany to Iowa county, Wisconsin, and thence to the station. By
 station it was disseminated all over the northwest, proving worth hundreds
 thousands if not millions of dollars."

Our new wheat, Minn. No. 163, came from a single kernal planted in
 2. In 1893, seventy-five plants grown a foot apart each way were harvested;
 1894 a small field plot was grown; in 1895 a one-twentieth of an acre; in 1896
 eral plots; in 1897 a small field; in 1898 several small fields, resulting in about
 te hundred bushels of seed wheat, which was sold to about fifty farmers and
 ted in two-acre lots in the various counties of the state. At an annual increase
 enfold this wheat could be so increased as to make the entire crop of the state
 even more years, or in fifteen years from the planting of the single parent seed.

Mr. S. A. Bedford, superintendent of the Dominion Experiment Farm at Bran-
 n, Manitoba, expressed the belief that the yield of oats in Manitoba had been
 eased on an average of two bushels per acre by the distribution of a few
 erior varieties during the several years since the establishment of the experi-
 nt farm at Brandon.

GREAT VARIATION AMONG WHEAT PLANTS.

Variability of individual plants of wheat is the basis for breeding. That this variation is considerable is demonstrated in many ways in our records of breeding wheat in the field-crop nursery where each plant has the same space of ground as each other plant. In 1892 ten best plants, chosen by inspection out of 400 plants from seeds selected out of the bulk grain of each of three varieties, showed great variation in the several characteristics of time of ripening, length of spike, and height of plant. Especially was there great variation in the date of ripening. The plants each had a space 12 by 18 inches in area in which to grow and develop their individualities. Among the four hundred plants of McKendry's Fife, for example, plants were found which matured in ninety-seven days, others requiring one hundred and twenty-seven days. Among Power's Fife the range was from ninety-eight to one hundred and twenty-two days; and among Haynes' Blue Stem plants the range was from ninety-nine to one hundred and twenty-eight days.

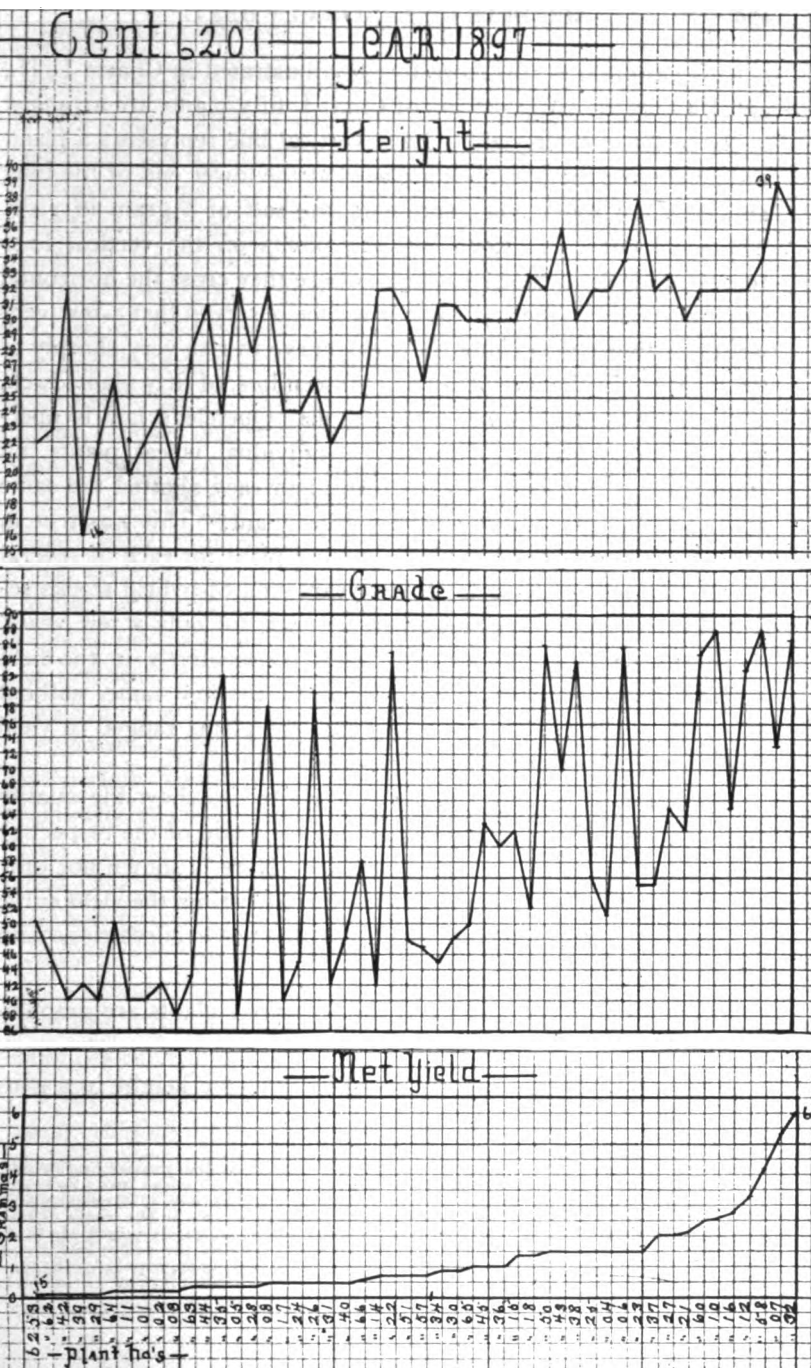
The ten plants which appeared to the eye as the best yielding plants out of the four hundred of each variety were harvested and notes taken as to height of plant, number of spikes, length of spikes, and yield of shelled grain. The following table shows the extremes of the variation in each case:

TABLE LIV.—Variation Among Best 10 Out of 400 Wheat Plants.

	Height of Plant	Length of Spikes	Number of Spikes	Yield Grams
Haynes' Blue Stem.....	31-39	4-4¾	19-31	15.4-19.4
Power's Fife.....	27-33	2¼-4	18-33	3.4-13.8
McKendry's Fife.....	30-33	3½-4	22-33	6.8-16.7

NOTE.—In Chart I are fifty wheat plants arranged from left to right in the order of their yield. Vertical lines represent the plants. Horizontal lines represent, in the lower section, yields in grams; in the middle section, grades expressed in percentages; in the upper section, heights expressed in inches. The figures at the left of each section show the value of each line. These fifty plants are from new variety springing from a single seed produced by crossing in 1892, and each year thereafter until 1897, selected to the best plant in one hundred, these plants being a part of the fifth generation of the cross and all from seeds from one plant of 1897.

CHART I.—Variation Among Fifty Wheat Plants. 6201-1997.



This variation is still more forcibly illustrated in Charts I., II. and III. In the lower section of Chart I. fifty plants are arranged in the order of their yield. Each vertical line represents a plant, the number of the plant being placed at the lower end of the line, and each horizontal line represents one-half of a gram in yield. The yield curve is drawn between points on the vertical lines representing the respective plants, where they cross the horizontal lines representing their yields. It will be observed that a few very large yielding plants cause the yield curve to rise very sharply at the right. Yield curves drawn of sixteen lots, of fifty plants each, all have this same feature showing that Quetelet's law is operative in the variation of yields of individual wheat plants, all from seeds of the same mother plant, and each allotted the same area of soil to grow upon as every other plant. This was true in the case of stocks selected to a single mother plant for each of several years, of stocks selected for a few years, and of hybrid stocks selected for several years and others selected for only a few years.

The fifty plants plotted here grew consecutively in the field crop nursery, i. e., the plants were taken as they came, without selection. The yield curve shows that the plants ranged in yield from a fraction of one gram to six grams per plant.

In the middle section the curve is plotted to show the quality or grades, expressed in percentages, of the grain of the respective plots as arranged in the lower section. Here is shown not only the widest variation, but also a wide variation from the yield curve in the lower section, though in general the grade curve rises with the yield curve.

In like manner the heights of the respective plants are graphically compared in the upper section.

Here, also, there is marked variation and the height in a gen

Quetelet's Law, which seems to be operative in the yields, grades and heights of individual wheat plants, and in the yields of varieties of wheat, may be briefly illustrated by taking the heights of 1,000 men of mature age, all from the same race and brought up in the same country. If placed in a row in the order of their heights, a line drawn over their heads is almost level throughout nearly its entire length. At the lower end it drops down sharply and at the upper end it rises sharply, i. e., owing to the law of variation from the usual type, which, by the force of heredity, is in general maintained, there is an occasional marked variation in either direction.

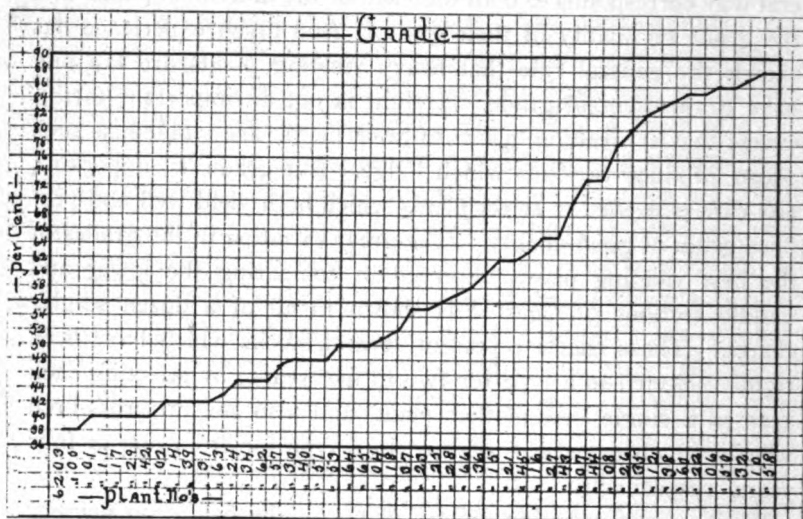
eral way corresponds to both the yield of the individual plants and the grade or quality of their grain. And much experience has shown the general rule that heavy yielding plants are tall and have grain of good grade. Height is not an important factor, except that in breeding, plants of great height are avoided, as such plants produce varieties which lodge. But grade is important, and care is needed to select plants which both yield well and produce grain of good quality. The great variation in the grades of the best yielding plants observed in comparing the lower and middle sections of Chart I is shown in all of a dozen similar charts. These charts represent several stocks which have been rigidly selected to a type for two to five years; by selecting each year to a single best mother plant, and also several cross-bred wheats which have been selected to a type for from one to four years, respectively.

Some of the variation among plants in the field crop nursery is due to inequalities in the soil and in other conditions. Insects and accidents may result in injury to some plants, and in rare cases some plants may have unusually rich spots of earth. As a rule, however, the unequal conditions are from causes which injure certain plants, and the selection of the best plant or plants practically is made from among those which have not been injured but have had the general good conditions of the field. Great care is taken to have the land in uniform condition. The field is prepared the previous year. Where fertilizing is needed it is done very carefully, usually by a bare or a green manure fallow. Commercial fertilizers could be evenly distributed, but since this form of fertility is not depended upon in Minnesota it is not desirable to use it.

Great variation among wheat plants which are the results of recent crossing between varieties has been observed in many cases. There is variation in all characters. Fig. LX. and the related text illustrate this variation.

Two hybrid stocks arising from two kernels produced by pollinating two flowers on the same plant of one variety with pollen from one plant of another variety of wheat are found to differ in

CHART II.—Variation of Wheat Plants in Grade of Grain.



NOTE.—In Chart II. the same plants shown in Chart I. are arranged from left to right in the order of their grades. In a dozen similar charts the grades have been plotted, but in only part of the cases do the curves conform to Quetelet's law.

CHART III.—Variation of Wheat Plant Height.



NOTE.—In Chart III. the same plants shown in Chart I. are arranged in the order of their heights. In this and in most of a dozen other similar charts made of wheat plants growing consecutively in nursery centgeners from single mother plants the height curve follows Quetelet's law, turning up sharply at the upper end and downward sharply at the lower end.

number of forms they will break up into, and in the time required to select them to a true type. In other words, hybrids vary in their tendency to greater or lesser variation from type, even when the parents of two cross-bred stocks are the same two plants.

In each one thousand plants of wheat there are a few phenomenal yielders, and the method of single-seed planting makes it practicable to secure these exceptional plants, and from these new varieties can be made.

By no means all the varieties made from single mother plants, those made by mechanically mixing together the seeds from several single mother plants, will prove large yielding varieties. Some plants grow vigorously when in the nursery where room and plant food are abundant, but when crowded in the field their progeny do not do well, and the variety is not a large yielder. It is found necessary to make ten new varieties, more or less, to secure one which is a marked improvement.

Quetelet's law is operative among varieties produced from single mother plants as is shown by the yields of thirty varieties produced from single mother plants grown in the nursery in 1892. When applied to the choicest varieties there is one or a few exceptional kinds. In Chart IV are plotted the averages of six seeds each of the eight varieties which were the best of their respective classes among the thirty wheats originated from single mother plants in 1892. Here No. 169 stands out prominently as the best yielding wheat. Out of these thirty wheats three varieties are giving strong proof of promise, and one variety, Minnesota No. 1, is especially promising. The Englishman who explained his success in breeding hounds by the terse statement that he "bred many and hung many," and the Scotchman who put philosophy in the single word "tops" when refusing long prices for the few best of his herd or flock, recognized the essence of Quetelet's law. This law should be more fully and broadly recognized in animal breeding and especially in plant breeding.

Put into practical form this law may be exemplified as follows: There are occasional plants of wheat, which upon being multi-

plied into varieties yield larger crops than the parent kind, adding one or more dollars per acre to the value of the crop.

(a) These best plants may be sought out in the nursery where the seeds are planted singly in hills, by choosing the few best yielding plants of good grade from among each thousand plants.

(b) When hundreds of varieties are originated from single mother plants, or from mixed seed from several superior mother plants, and these varieties are tested in the field, a few out of each hundred will prove to be valuable new varieties.

(c) These foundation stocks will serve as better foundation stocks for further improvement by continued breeding, whether by selection alone, or by crossing followed by selection.

When applied to plant breeding, and animal breeding also, the most important point in connection with Quetelet's law is that *the selection of foundation breeding stocks should be made most carefully from among very large numbers*. The larger number the plot in the chart the greater the chance there is for securing phenomenal plants at the upper end of the line.

Science in Selecting and in Mating.—In animal breeding, men have become expert in that artistic ability which enables the live stock expert to so select and mate his animals as to rapidly improve a herd or to establish a new breed. In the breeding of swine, some of the beef breeds of cattle, and meat producing breeds of fowls, the individual appearances as form, color, handling quality, etc., have been mainly depended upon in selecting the superior individuals, and in determining which individuals would blend in mating so as to best unite the desirable qualities and avoid the weak points of each. In breeding trotting horses and dairy cows, on the other hand, many of the most successful breeders have paid comparatively little attention to the form and other appearances, but have selected on the basis of actual performance records, as in the mile trotting race, or in pounds of milk and butter produced. Where actual performance can be recorded or where other principal characteristics, as amount of food required for a pound of grain, or the strength of fecundity, as determi-

by the number of young reared, can be reduced to figures, such as, as a rule, of greater weight in selecting among individuals than mere form or color or other outward appearances.

In the breeding of wheat, yield per acre and the grade of the grain have been used as the most important characteristics to be considered, and in making a choice among plants attention has been paid to little else. Other qualities, as rust resistance and quality of the gluten in the grain, have also come up for careful consideration both in the selection of the best varieties and of the best plants to increase yields and also to make crosses, the two parents of which if combined would make the greatest improvement.

It was found desirable to express all these qualities in some simpler form than in a mere tabulation of percentages. The curved line method of graphically displaying the yield and other characteristics have been found very helpful.

Chart IV containing graphic expressions of the various qualities of our three best old and eight best new wheats is introduced here for this purpose. (See the notes under the chart.)

1st. It serves as a method of comparing the value of the more intrinsic qualities with those of less value or with the mere fancy points in each variety or individual.

2d. This is a graphic way of expressing the many qualities of several complex individuals. It is a means of gaining a more comprehensive knowledge of the relative merits for specific purposes of the several varieties or individuals.

3d. The characteristics of various individuals or varieties thus graphically shown aids in selecting the two parent individuals in crossing so as to best combine the desired qualities and eliminate the undesirable characteristics of the two parent stocks.

Intrinsic Qualities vs. Fancy Points.—In Chart IV yield stands as the most important characteristic in the graphic score card. If the six sections were each represented on a percentage score card its relative value, yield would properly be given the largest space and grade might take second place, grade meaning appearance of the grain—its ability to stand on appearances before the market.

The following named values, for purposes of illustration, are an aid in properly interpreting the chart :

PERCENTAGE SCORE CARD FOR COMPARING VARIETIES OF WHEAT.

1	Yields per acre	45
2	Grade of grain	20
3	Rust resistance	10
4	Quality of gluten.....	10
5	Amount of gluten.....	5
6	Coefficient of rise of gluten	10

100

Giving yield such a prominent place as compared with other qualities might appear wrong. But the total weight per acre is the main factor in giving profits to the wheat grower. Several sections relate to the quality of the wheat, viz., 2, 4, 5, and 6, making a total of 45 per cent. almost too much in proportion to what is given for yield.

It will be observed that the rust-resistance curve in section 4 corresponds closely to the yield curve in section 1; i. e., those plants

NOTE.—In Chart IV. are shown graphically several of the leading characteristics of eight newly-originated wheats, and on the right side of the chart three old standard wheats are shown. Of these latter, Minn. No. 51, Haynes' Blue Stem, is the parent of the best new wheat, Minn. No. 169; and Minn. No. 66, Power's Fife, is the parent of Minn. No. 149.

The vertical lines represent the respective varieties which are given by number or name at the bottom of the line. In each of the six sections there are horizontal lines representing units of the various qualities. These run only through the range of figures, as given at the left ends of the lines, which include only the variations in yield in grade or in other qualities respectively, in their respective sections, and not the entire yield, etc. This graphic language is new to the common reader, but if once mastered it often conveys the ideas in a much more clear and comprehensive manner than would mere words and figures. The various sections have been given the same proportion of the whole height of the chart as each quality is given in the percentage score card in the text.

In section 1 the yields per acre are expressed in bushels of 60 pounds each, and since the yield is the quality to which the most value is attached the new and also the old varieties are arranged throughout the chart in the order of their yields.

In section 2 the grades are expressed in percentages, thus making the comparison of yield and grade comparatively easy in the two sections.

In section 3 the relative rust resistance is shown in percentages.

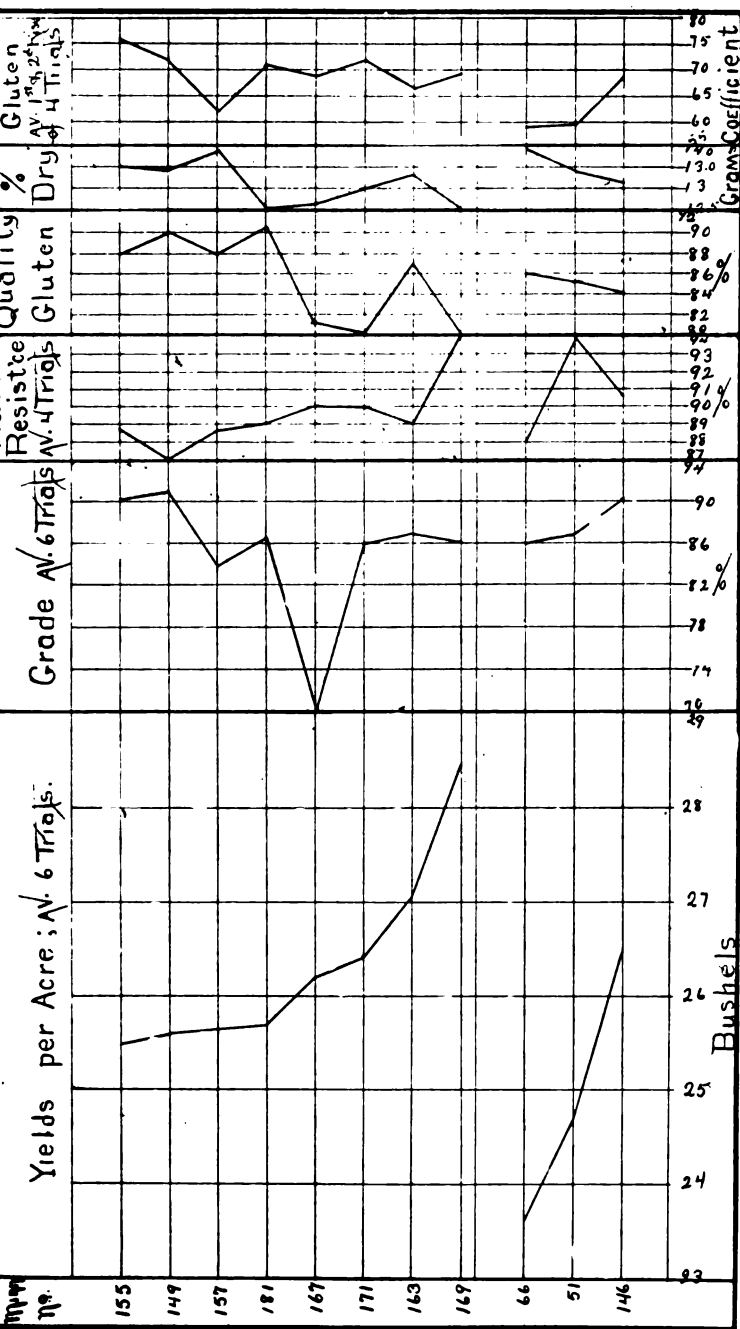
In section 4 is given the quality of the gluten as determined by the gluten test of the flour from each variety.

In section 5 is given the percentage of gluten in the flour from each variety.

In section 6 is given the quality of the flour as determined by the baker's sponge test, expressed in the volume of loaf produced by each percentage unit of gluten. This is obtained by dividing the grams of dry gluten in a hundred grams of flour into the volume of loaf of dough produced from the hundred grams of flour. These figures represent the averages between the volumes of the first and second rise of each kind of flour.

This graphic score card has been drawn so as to give the same relative space on the card to each quality as is given in the percentage score card above.

CHART IV.—Graphic Score Card of Varieties of Wheat.



which strongly resist rust are as a rule, able to yield well. It will be observed that in this percentage score card and also in the graphic score card no place is given for uniformity to type, length of spike, height of plant, and other points which are not relevant to the yields and quality which give value per acre to the farmer.

Score cards sometimes used, as by poultry judges, have ninety-five per cent. of their values placed on the mere fancy points, as the form of comb, and wattles, color of wing feathers, character of markings of the body feathers, the poise of the "stocking" feathers and even the color of the scaly skin on the lower portion of the leg. Weight is given a place and in some cases is given a relation to value, but quite as often a bird is scored down because it weighs above as below the standard, and it may thus come to be used as a mere fancy point. The actual amount of percentage of lean meat on the breast and legs of the fowls of a meat breed is overlooked, though it could be determined with fair accuracy by handling the fowl. "Fuss and feathers" have but little place in breeding plants and animals which are used for the production of foods and other useful products, though they may properly be taken into careful account in breeding pigeons, pet dogs, pansies, chrysanthemums and other animals and plants produced for pleasure.

Graphic Score Cards Used in Crossing.—Choosing animals to mate that the most nearly ideal young may be produced, and determining which varieties or individual plants of wheat to cross-pollinate to produce the most useful new varieties, are very difficult problems. Mere art may oftentimes suffice; and extensive mating followed by intelligent and careful selection will often result in the production of some good individuals. But to make the most rapid progress—to use a given amount of time and means to the best advantage—the many qualities of each parent should be considered, and the selections should be such as to unite the greatest number of strong points with the fewest weak ones.

Chart IV would aid in the selection of varieties between which crosses are to be made. Minn. No. 169 stands out prominently as one parent to choose for crossing. Minn. No. 163 being the

next best yielder of good grade, fair in rust resistance—a point in which Minn. No. 169 is very strong,—good in quality of gluten, very good in the amount of gluten, and fair in amount of loaf a given amount of gluten will make, would well mate the large yielding Minn. No. 169.

Minn. No. 66 would not seem so promising to use for crossing with Minn. No. 169 as would Minn. No. 163. Its smaller yield is not sufficient to overcome the advantage of its superior weight per bushel and its slightly greater per cent. of dry gluten; and, besides, it is below Minn. No. 169 in rust resistance and in the coefficient of its ability to rise in the loaf.

A score card at best can represent only part of the factors which the breeder must take into consideration. One quality not placed in the graphic score card, because common only to the Blue Stem varieties, is the weakness of the chaff in holding tight about the berry. In case of Minn. No. 169 there is some loss from shelling and from the spreading chaff allowing the bran of the berry to be exposed to rains, dews, and sun and thus rendered brittle and light colored. Nos. 163 and 66, being Red Fife varieties, have tightly clinging chaff, and would be equally well adapted to crossing with this new Blue Stem variety to increase the strength with which the chaff holds to the grain.

Since Minn. No. 169 is the better wheat, the best progeny would probably be the few selected from the cross-bred stocks which resembled that parent. And by producing the progeny in very large numbers and seeking the best, those plants most nearly combining all the good qualities of both parents could be found and used in making new varieties. Experiments might prove that it would be advantageous to use Blue Stem wheat a second time, making the cross-bred wheats three-fourths of the blood of Minn. No. 169 and only one-fourth the blood of Minn. No. 163.

The many questions which arise as to how best to proceed in making crosses are somewhat difficult of solution because of the large number of plants which must be used and the long series of years through which the resulting varieties must be tested in the field and in the mill before final results are reached and the varie-

ties have won a place among the wheats which are chosen for general distribution throughout the state.

HOW NEW VARIETIES OF WHEAT ARE ORIGINATED.

The breeding of field crops was begun by the Minnesota Experiment Station in 1889. In case of wheat, corn, oats, and barley, of which many varieties exist, the effort was to first secure the best obtainable kinds, that the work of breeding might be centered on making the best varieties still more useful. In case of timothy, clover, and other species which had not been broken up into agricultural varieties, systematic breeding was at once begun, using the common kinds of those crops for the foundation stocks. Encouraging progress was made from the start with timothy, though the process is of necessity long, because of the perennial habit of this grass, necessitating two or three years for the growth and selection of each generation. Severe winters have destroyed stocks of common red clover, and very little has been accomplished with that crop, excepting that something has been learned as to methods of breeding it. While most effort has been expended on wheat, and most accomplished, numerous other crops have been dealt with in the field crop nursery. Since each species needs a somewhat different method of breeding, the work with oats, barley, millet, flax, field peas, beans, and brome grass has given a larger knowledge of the subject, aside from the production of new varieties of these crops.

WHEAT BREEDING BEGUN IN 1889.

In 1889 Red Fife and Blue Stem wheats were crossed as found growing on several farms in the Red River Valley. All the resulting kernels were accidentally destroyed. In 1890 a large number of wheat flowers were cross-pollinated at Warren, Marshall county, Minn., and fourteen grains were harvested. These seeds were planted near Fargo in 1891, and the resulting plants were shipped by express and lost, thus again destroying the start in the breeding of these two famous hard wheats. Valuable

cts, however, were secured. Eight out of thirteen of the resulting plants, inspected when in blossom, proved to be true crosses, showing that these two wheats will cross fertilize.

Field Crop Nursery Begun in 1890.—The growth of individual plants of timothy and wheat in 1890 and 1891, planted in hills the seed in a place, had demonstrated that it was practicable and desirable to deal with individual plants in breeding these field crops.

At Fargo and Power, N. Dak., 400 kernels of each of eight wheats were planted singly in hills 12 by 18 inches apart, in 1892. The following named varieties were used: Power's Fife, Minn. No. 66; Glyndon 818, Minn. No. 480; Glyndon 753, Minn. No. 16; Haynes' Blue Stem, Minn. No. 51; Risting's Fife, Minn. No. 16; Glyndon 811, Minn. No. 168; and Glyndon 761, Minn. No. 81. Besides selecting the best plants from each variety, and making many crosses among the best plants, the variation of each variety grown in this nursery way was critically studied, as mentioned in a previous paragraph.

IMPROVING A GOOD VARIETY OF WHEAT.

Besides the numerous varieties of wheat which have been in the field crop nursery for some years, the station has recently placed nursery plots, under present plans of breeding, stocks of a dozen varieties which have proven to be the best out of the several hundreds tried for a series of years in field trials, and several promising varieties originated by crossing which having been for some years in field trials have been returned to the field crop nursery to be used as foundation stocks from which to produce still other new varieties. One of the collected wheats, Bolton's Blue Stem, Minn. No. 146, received from Thomas Bolton, Park River, N. Dak., stands out prominently as the best variety among those collected prior to 1894. In ten yields it averaged nearly two bushels more than the other best yielding kinds, and is among the best in percentage and quality of gluten. The methods employed with this wheat will illustrate the plan of selecting wheat to use at present.

Breeding Bolton's Blue Stem Wheat, Minn. No. 146.—In the spring of 1898 there were selected from bulk grain, grown in



Fig. 265. Planting wheat in the field crop nursery. The planting frame consists of two 2x10 planks 42 feet long, held together by movable cross-ties. On the inner edge of each plank a nail is driven every four inches. A cross-board 52 inches long is placed with its ends against these nails. Notches every four inches along the edge of this cross-board indicate the position of hills of wheat. When one row is planted the board is pushed forward four inches against the next two nails.

the field trials the previous year, 1200 kernels of Minn. No. 146. The hardest large kernels were chosen, and these were planted singly, in hills four inches apart each way. These kernels were

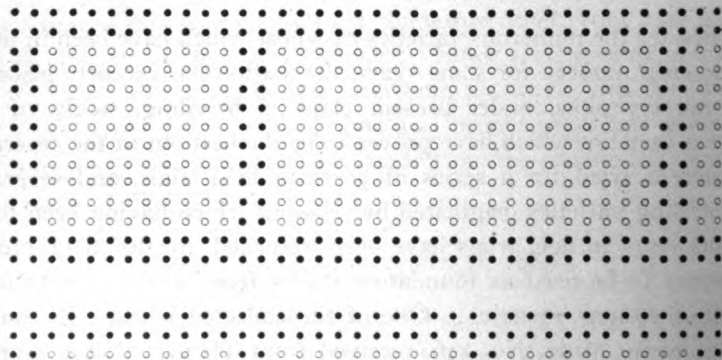


Fig. 266. Plan of planting nursery wheat. The circles represent plants within the *centger, the dots the border plants. The 18-inch alley is widened to 34 inches by the removal of the border rows either side.

planted by using the planting frame shown in Fig. 265. This frame is forty-two feet long, and fifty-two inches wide between the planks, giving room for fourteen plants crosswise and one

*Asterisk Refers to the plot or group of plants grown from seeds of a single mother plant.

hundred twenty-four lengthwise. The plots, or "frames," of plants are placed eighteen inches apart so that there may be alleys in which the workmen may stand when cultivating and harvesting. The alleys necessitate throwing out the border plants, since these have more soil and sunlight than do those in the center of the plot. The outer two rows are in all cases discarded, leaving the plot ten plants wide and one hundred twenty long, twelve hundred plants in the full frame. The plan of planting is shown in Fig. 266. Where the supply of seed is small, as in the case of some newly-crossed plants, the two border rows are planted with another variety of wheat, a bearded kind being used around beardless wheat, and vice versa. And when a limited number of seeds of several varieties or stocks are planted in the frame, they are separated by two rows of "border" wheat, as shown in the diagram.

The system of numbering in use has proved very simple and

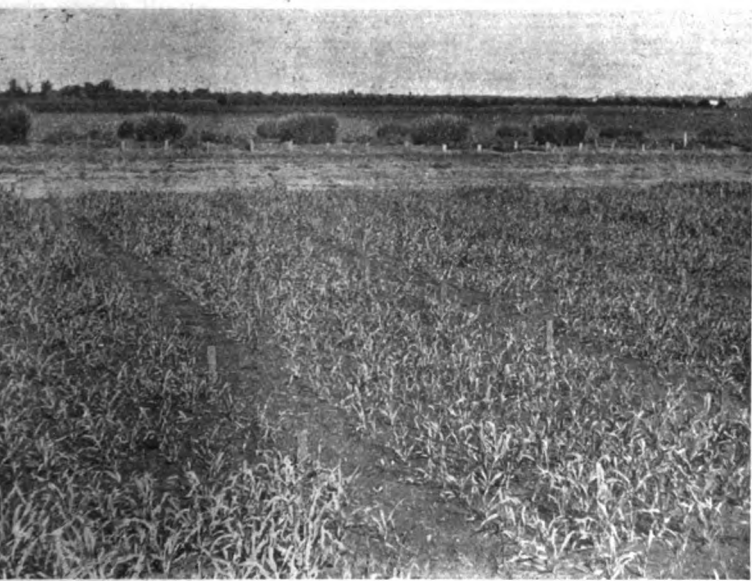


Fig. 267. In the foreground is the field crop nursery when the plants are several inches high. In the background are shown newly-originated varieties of *Bromus inermis* and of timothy.

convenient, and is adapted to an extensive system of records. The first plant of the first plot or stock of wheat is numbered 101, and if there are not more than 100 plants in the plots the first plants of the next plots are 201, 301, etc. If some century, as the eighty-fifth, for example, contained a full frame of twelve hundred plants, they would be numbered from 8501 to 9700, inclusive; and the first plant of the next plot 9701. In case there are only a few plants in the centgener, as in the first generation of a cross-bred stock, the last numbers of the hundred will be blank, since it is best to begin the numbers for the succeeding stock on the even hundred and one. This is a great help in running back the history of any given stock through the various year books in which are kept the planting notes, the harvesting notes and other data gathered annually, and aids in compiling a history of any stock to which an especial interest may have become attached. In harvesting, each plant is given its actual nursery number, as 1161, and this number together with the year always makes it possible to find in the storage boxes, where the seeds from all choice plants are preserved, the envelope containing seeds of any plant which may be desired; and it also facilitates reference to the notes wherever they may have been recorded.

Wheat Crop Nursery History Book.—After the notes of several years had accumulated the station had books of printed blanks made in which were recorded the histories of all nursery stocks of each kind of crop, as wheat, oats, barley, and field peas. Table LV. shows the notes for one year. This extends over a double page, and a similar page is used for the notes of each year. The margins of succeeding leaves are trimmed off showing the three left-hand columns of the first page, that the one set of names and numbers may be used for the blanks for each of ten years.

Note:—Table LV. is a page from the Crop Nursery History Book, into which are carried the notes of the best plants which are selected from which to plant nursery plots the next year. These notes are copied from the Nursery Year Book, (see Table LVII.) and from the envelopes on which are placed data gathered at harvest time and in the seed laboratory where the seeds are weighed and inspected. Twenty pages, with printed blanks as in this table, are set apart for each group of stocks, two pages being required for the notes of each year. The numbers in the third column are written with red ink and are used much as names for the respective nursery stocks. Succeeding pages have their margins clipped off, showing the names of the varieties, and the red numbers on the first of the ten pairs of pages.

Names of Varieties		Minnesota No.	Red No.	Century No.	Nursery No.	Height of Plant	Days Maturing	Spike			Chaff			Berry					Names of Crosses	Numbers of Crossed Plants	No. of Crossed Heads	No. of Flowers Harvested	True Cross	Rust	Net Yield	Tabulated in C. N. Y. B. Page	
								Number	Length	Color	Smooth or Hairy	Bearded or Awntless	Holds, Per Cent.	Color	Size	Form	Condition of Bran	Plumpness									Grade
Names of Parental Stocks I. G.	Bolton's Blue Stm	146	1	10501	10519	47	107	8.8	M	H	A	85.88	85.82	85	85									77.0	84		
	Weiman's Fife	528	2	24101	24123	37	99	7.9	M	S	A	87.95	87.90	91	93									34.4	104		
			3	24101	24184	46	99	5	9	N	S	A	89.96	95	93	90	95							34.0	102		
			4																								
			5																								
	McKendry's Fife	181	6	9301	9302	42	106	6.9	M	S	A ^b	90.96	96.91	94	95									26.4	80		
			7		9357	45	107	8.8	M	H	A	87.94	90.88	91	92									18.0	82		
			8																								
	Preston	188	10	11801	11840	44	106	7.1	R	S	B	90.94	90.90	85	90									65.4	90		
			12		11849	46	106	6.9	S	R	S	B	89.92	91.90	86	90								104.7	90		
			13																								
	Advance	185	15	13101	13123	40	106	5.1	M	S	B	83.95	92.90	87	94									45.1	92		
			16		13189	41	107	4.1	W	S	B	89.90	90.90	82	89									9.6	94		
			17																								
	Glyndon 811	168	18	22901	22929	43	99	7.9	W	S	A	90.90	93.90	90	90									45.1	96		
			19		22938	44	100	7.1	M	S	A	88.88	90.88	88	89									45.1	96		
			20		22940	44	99	9.8	W	M	A	91.90	91.89	88	90									86.1	96		
			21		22940	44	99	9.8	W	M	A	91.90	91.89	88	90									86.1	96		
			22		22987	45	100	8.8	M	S	A	88.94	93.90	90	92									66.3	98		
			23																								
	Bolton's Blue Stm	146	24	26301	26322	42	99	7.7	M	H	A	81.85	88.87	78	85									14.4	104		
			25		26387	49	101	4.1	S	S	A	90.95	87.91	85	93									64.6	106		

TABLE LVI.—Blank Form as Made up from the Crop-Nursery History Book, Showing the Important Facts of Several Promising Stocks for Five Years.

Names of Parental Stocks.	1894				1895				1896				1897				1898			
	Nursery No.	Strength	Rust Resistance	Grade	Net Yield	Nursery No.	Strength	Rust Resistance	Grade	Net Yield	Nursery No.	Strength	Rust Resistance	Grade	Net Yield	Nursery No.	Strength	Rust Resistance	Grade	
Power's Fife.....	185	1781	85 85	90 7.7	13003	80 88	93 26.	13531	90 83	89 18.	4916	86 80	83 5.	15724	92 92	96 5.6				
Power's Fife.....	483	1752	86 87	91 5.6	11247	80 86	92 21.2	13223	90 45	88 16.	4741	85 88.5	78 3.0	15526	91 99	93 5.4				
Haynes' Blue Stem.....	487	1814	91 91	89 2.3	16708	83 93	90 15.5	14024	91 90	85 12.2	5174	87 89.	74 5.8	15921	91 98	92 4.0				
Haynes' Blue Stem.....	489	1846	90 93	88 4.1	18526	81 95	89 18.3	14226	91 92	86 12.9	5351	88 90.	75 7.0	16127	92 96	90 2.6				
Power's Fife X H. B. S.		1751 1824	93.....	2.8 2.1	11015 17504	90.....	11 3 6.5	17140		7.	9248		40 4.6	20223		34 92 4.3				
H. B. S X H. B. S.		1828 1828	90.....	2.8 2.8	17508 17625	88.....	10.3 12.2	17 52		4.8										
H B S. X G. 763.....		1824 1800	96.....	2.8 5.4	17525 15531	92.....	12 2 9.2	17155		4 5	9703	100	81 3.2	21122		95 89 9 7				
H. B. S. X P. F.		4833 1962	95.....	4.4 7.7	15408 23011	92.....	17.1 17.6	16936		9.6	7501		81 5.8	18425		99 91 5.7				
											7504		80 5.2	18521		98 84 3.6				

In Table LVI. are collected the most important items of several stocks for a number of years illustrating how they can be brought together from the history book that the best nursery stocks may be chosen for multiplication and the poorer ones discarded.

Two small fields of one to two acres each are used for the cereal crop nursery, and two of similar size for the leguminous crop nursery. Only one of the two fields is used each year, the other being subjected to a preparatory process, that the land may be in uniform condition and free from weeds. The field which is not in use is sown to a green crop, as peas or oats, which is plowed under or mowed for hay or silage as the needs of the soil may demand. Care is used to keep the soil in good heart, but not so much as to cause the plants to fall down, and to have the surface uniform in fertility and in mechanical condition. These small fields are admirably adapted to the purpose. Surface drainage is especially attended to, that no injury may result from the soil being washed about during heavy showers. The land is fallowed and no horses are allowed on the field in the spring, but it is pulverized and made into a fine seed-bed by using the hand hoe and garden rake.

Planting the Seed.— These seeds are planted by hand as shown in Fig. 265. A pointed dibble is used and each seed is placed one and a half inches deep and carefully covered. The plants are cultivated by means of small hand-weeding claws as soon as the plants have appeared, and as often afterwards as the condition of the soil or the presence of weeds may require. The plants are all carefully inspected before the plants have formed ears, and whenever two plants are found in a hill one is removed.

The Harvesting is mainly a matter of elimination. The two outer rows are first clipped off with sheep shears, care being taken to remove all the heads and not to injure the remaining plants.

Recording the Notes.— The presence of numerous stocks necessitates the use of system in recording the notes. The planting

notes are entered each year in a Crop Nursery Year Book, referred to in the notes as C. N. Y. B. 1899, C. N. Y. B. 1900, etc. In this book are entered the planting records, including the nurs-



Fig. 268. Removing the border rows.

number of the mother plant of the previous year; the century number of the present year, thus, 101, 201, etc.; the Minnesota variety number; the variety or class name; the date and the number of seeds planted. At harvest time general notes are made in the



Fig. 269. The men at the left are clipping out all the plants except the best, while those in the center are taking notes on the best plants and harvesting them, saving the heads in envelopes. The field-house where the books are kept at harvest time is shown in the background.

book, on the strength and other characteristics and facts regarding the entire plot, leaving all notes on the individual plants to be made on the envelopes mentioned in a future paragraph.

the left-hand column are Roman numerals and capital letters. Stocks classed under "I." are being improved by selection alone, while all marked, II., are results of crosses which are being selected for large yield and uniformity of type. The character, IV., is used to designate other stocks which are in experiments where a study of methods of breeding, rather than the making of varieties, is the object sought. Columns are also placed in this book for the insertion of the pages in the Wheat Crop Nursery History Book (W. N. H. B.) and in the Crop Nursery Year Book (C. N. Y. B.) of the previous year. On the following page is a copy of the blank form used in the year book, in which the planting notes only have as yet been entered.

In making the selection, careful men clip out all but the best plants. In going over the plot the first time about half the plants are removed. A second time half or more of the remaining plants are removed, and a third or fourth time through the plants are reduced to five to ten per cent of the whole number. Thus among twelve hundred plants of Minn. No. 146 only about seventy-five are left standing. In other cases where only one hundred seeds were planted, ten of the best are left for harvesting. The preference is usually given to plants which have several culms of nearly the same height, bearing large well filled heads. See p. 270.

Harvesting Choice Plants.—Each of these ten, or seventy-five plants, as the case may be, is given a nursery number. Large paper envelopes are given numbers corresponding to the numbers of the choice plants. On these envelopes is a mimeographed blank form into which are written all the notes regarding the plant, the heads of which are placed within. The spikes are cut without any straw, and placed in the envelopes and these envelopes in turn are placed in paste-board boxes $7 \times 10\frac{1}{2} \times 12\frac{1}{2}$ inches in size. In case spikes are not dry it is necessary to pack the paste-board boxes loosely and to leave the flaps of the envelopes open so that the grain may dry out and retain strong germinating power.

Seed Selection in Winter.—In the winter season the unthreshed heads of the selected plants are weighed. These gross weights

TABLE LVII.—Blank Form as Filled Out in the Crop Nursery Year Book.

	Nursery No. of Parent Plant in 1898	Cent. No. 1899	Minn. No.	NAME OF VARIETIES, AND OF VARIETIES USED IN MAK- ING CROSSES.	Date Plant'd	No. of Seeds Plant'd	Plot or Centenger					
							Type	Strength	Rust	Smut	Ergot	W.C.N.H. B (221) Page	C.N.Y.B. (1898) Page
IA	138 601 651 701 921	101 601 651 701 921	66 61 181 287 3401	Power's Fife	4-18	100	.....	.....	.....	.....	1	.....
IE	1546 2904 4601	1201 2201 3401	157 157 155	Haynes' Blue Stem	4-18	100	.....	.....	.....	.....	1	.....
				McKendry's Fife	4-18	100	.....	.....	.....	.....	1	.....
				McKissick's Fife	4-18	100	.....	.....	.....	.....	1	.....
				Glyndon 763	4-18	100	.....	.....	.....	.....	17	.....
IG	6204	4501	226	Glyndon 818	4-19	100	.....	.....	.....	.....	17	.....
				Blount's Fife	4-19	100	.....	.....	.....	.....	37	.....
IH	6303 6803 7003	4601 5001 5201	231 264 266	Improved Fife x <u>Horn Blende</u> x Blodette.....	4-19	100	.....	.....	.....	.....	37	.....
				Pringle's Defiance.....	4-19	100	.....	.....	.....	.....	37	.....
				Fultz x Horne Blende	4-19	100	.....	.....	.....	.....	37	.....
				Gypsum	4-19	100	.....	.....	.....	.....	37	.....
IIC	11801 15101	289 292		H. B. S. x Glyndon 761.....	4-21	1180	.....	.....	.....	.....	.....	.....
				Rising's Fife x Rising's Fife	4-22	1180	.....	.....	.....	.....	.....	.....
IIE	16924 17022	20301 20401	494 495	IMPROVEMENT BY CROSSING AND SELECTION.			.....	.....	.....	.....	.....	.....
				H. B. S. x H. B. S.	4-24	100	.....	.....	.....	.....	54	.....
				H. B. S. x Power's Fife	4-24	100	.....	.....	.....	.....	54	.....
				Rising's Fife x H. B. S.....	4-24	100	.....	.....	.....	.....	98	.....
IIE	18223 18375 21122	21601 21801 25401	21601 21801 25401	Rising's Fife	4-24	100	.....	.....	.....	.....	98	.....
				Power's Fife	4-24	100	.....	.....	.....	.....	98	.....
				H. B. S. x Glyndon 753.....	4-25	100	.....	.....	.....	.....	107	.....
				H. B. S.	4-25	100	.....	.....	.....	.....	72	.....
IIG	21725 22030	26201 26501	26201 26501	McKendry's Fife x Power's Fife	4-25	100	.....	.....	.....	.....	72	.....
				H. B. S. x Glyndon 818.....	4-25	100	.....	.....	.....	.....	72	.....
	26638A 12070 22676	27001 27201	146 184	Bolton's Blue Stem x Preston	4-25	4	.....	.....	.....	.....	95	.....
	22676 10228 286 5	27201 191 27501	x 191 146	H. B. S. x McKendry's Fife	4-25	2	.....	.....	.....	.....	95	.....
			Power's Fife	4-25	2	.....	.....	.....	.....	.....	95	.....
				Bolton's Blue Stem x Advance	4-25	1	.....	.....	.....	.....	95	.....



270. The plant at the right has culms very uneven in length, while that at the left has no very tall culms, but many of nearly the same height.

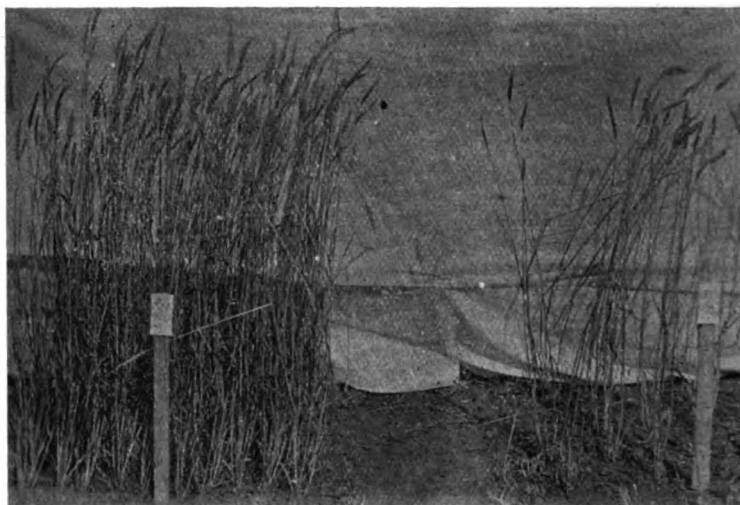


Fig. 271. At the left is shown a plot of 100 plants with the border rows away. At the right, ninety of the centgener have been removed leaving the best ten plants to be harvested and stored in the envelopes.



Fig. 272. Taking notes and harvesting the best nursery plants.

Table LVIII.—Blank Form on Envelopes.

G. "98" Nursery No. 24126.

WHEAT	
Date Ripe.....	7/30
Height.....	37
Stiffness.....	88
Rust.....	3
Spikes—Number.....	7
Length.....	8 c. m.
Glume—Smooth or Hairy.....	S
Bearded or Awnless.....	A
Holds.....	87
Glume—Color.....	95
Size.....	
Form.....	94
Ergot.....	0
Loose Smut.....	0
Stinking Smut.....	0
Plumpness.....	91
Condition of Bran.....	90
Grade.....	93
Gross Yield.....	6.0
Net Yield.....	4.4
N. H. B.—221—Page.....	40
1898 C. N. Y. B.—220—Page.....	100

give data for eliminating more of the poorer plants, thus avoiding the expense of shelling all but a small number of the very best plants. Before weighing, notes are taken as to the number and length of the spikes, and any other notes which special experiments may require. The shelling is carefully done by hand.



Fig. 273. The seed laboratory where the seeds are stored, where, in winter, all the seeds are weighed and threshed out and the best are selected for planting the next year.

The seeds are then weighed, judged as to quality or grade, and other notes, as the color and form of berries, may also be made on the grain if desired, as in case of cross-bred stocks.

These notes on the right margins of the envelopes can all be laid side by side where the grades and other qualities may be easily compared and the best plants chosen as mother plants of

nursery centgeners the next season or for mothers of new varieties.

Varieties are not at once started from mother plants chosen the first year from among those springing from the 1200 seeds selected from bulk grain and grown in a "full frame." Several of the best plants are chosen and centgeners—one hundred or more plants from a single mother plant—are planted the next season. Here the "strength of row", the average yield of all the plants of the centgener, and other characters, are recorded.



Fig. 274. Small plots where the seed from the nursery plots is being increased to quantities sufficient for field trials.

After choosing the best plants from the best centgeners the remaining seeds are harvested in bulk and at once multiplied. Thus while a few of the very best plants are used for further breeding in the nursery, the bulk of the seed from the centgeners is multiplied, forming a variety which soon enters the competitive field trials.

Recapitulating the Steps in Breeding by Selection we have:
1st. Secure those varieties which yield large crops of wheat of superior quality. 2nd. Plant a large number of the seeds from the bulk grain the first year in the nursery. 3rd. By some suitable method find the choicest plants which are most promising for mother plants. 4th. The second year plant from each of

these a hundred or more plants. 5th. Choose from the strongest stocks the choicest plants as mother plants with which to continue the breeding. 6th. After discarding the poorer plants of these strongest stocks of the second year, save the seeds in bulk from the remaining plants. 7th. Use this bulk seed the next year to plant a small field plot. 8th. The following year there is sufficient seed to sow a twentieth acre plot where it can be regularly compared with the other wheats in the variety tests. 9th. When the twentieth acre plot is harvested there is sufficient seed, if the variety is promising, to supply seed to other stations. By testing the varieties several times the average yields show the relative values of the varieties. 10th.



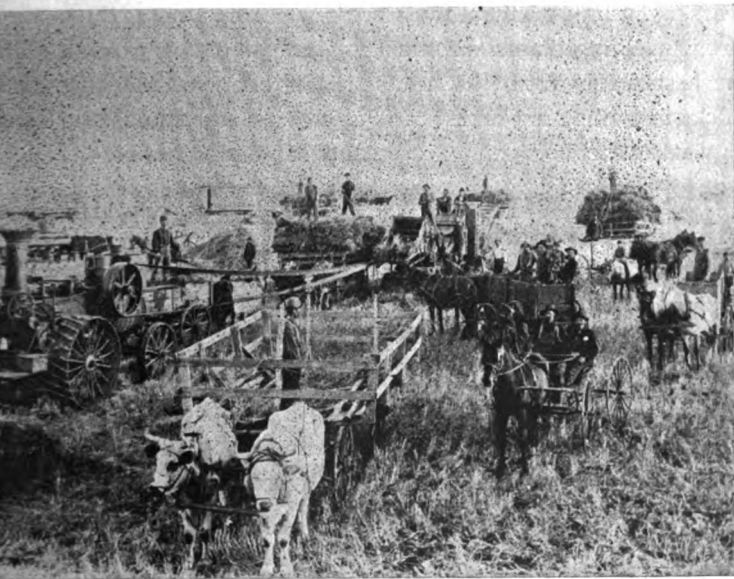
Fig. 275. Uniform field trial plots, $\frac{1}{20}$ acre each.

At least the larger part of the new varieties can now be discarded and only those of greatest promise need be retained. 11th. After testing a wheat one or two years it is milled and the flour is tried, as by the gluten test and the baker's sponge test. 12th. The field tests are continued for a series of years and a new wheat is disseminated when it has been fully demonstrated that it is of special value in the entire state or in some particular locality in the state. 13th. Great care is used in distributing new wheats of promise. They are sold to farmers who have good lands free from noxious weeds and who will raise crops of the seed for sale.

Selecting varieties for each soil and each locality must, of necessity, proceed but slowly. Promising varieties are very re-



276. The first five-acre field of Minn. No. 163 wheat, in 1898. This variety came from a single plant in 1892, and was first disseminated in 1899.



277. A large steam threshing outfit in operation in shock threshing. Self-feeding and measuring attachments; "basket" grain racks; hundred bushel grain boxes or tanks on the wagons; cook shanty on wheels where the crew is "boarded."

luctantly discarded. But the introduction of many varieties would lead to a confusion of names, and with the aid of the several substations it seems wise to reduce the number to be distributed to the minimum. If several are disseminated within a decade, each will find that portion of the state where it is adapted to produce the best crops of wheat.

CROSSING FOLLOWED BY SELECTION.

Bolton's Blue Stem and *Minnesota No. 163* have been chosen as two wheats to use as foundation stocks in producing cross-bred wheats. Crossing followed by selection as a means of producing improved varieties of wheat has some features not necessary in the improvement by the method previously described by selection alone. To secure stocks for crossing the varieties are first introduced into the field crop nursery in full frames of bulk seed, and are subjected to rigid selection for two or more years, as in improvement by selection. From among these stocks strong yielding plants are taken for the parents of crosses. Thus the best plants from the best varieties are used for foundation stocks in making out-crosses and in-crosses, and time is not wasted on weak varieties nor on weak plants of good varieties.

How Wheat is Cross-Pollinated.—The stocks of wheat to be used for crossing are grown in the nursery, where each plant has an area 4 x 4 inches square. When approaching the flowering period superior plants are chosen and marked with a card placed in a tin label, which is borne by a tall stake. From some of the largest spikelets all the florets are removed except a dozen, more or less, of the strongest ones. This is done just before these florets are ready to blossom, that the anthers may be removed before they break open and cause self-fertilization. This work must be done with much care. If handled roughly the florets are often so injured that fertilization is not effected. If the anthers are permitted to become too nearly ripe they usually burst open while being removed, and cause self-fertilization. Since the florets open very early in the morning it would seem wise to remove the an-



Fig. 278. Crossing wheat.



Fig. 279. No. 1—Blue Stem spike chosen for female flowers; 2—same after removal of all florets except 14 of the strongest; 3—Pike spike from which pollen is used.

thers in the afternoon and apply the pollen early the next day; or in case the florets are not yet ripe, to add fresh pollen the second day. General experience is the guide so far, since exact experiments to determine the best time and manner of removing the anthers has not been completed.

Fig. 280 shows the operator removing the smaller spikelets at the base of the spike. The upper spikelets are also removed as shown in Fig. 279. When all the spikelets excepting the six or

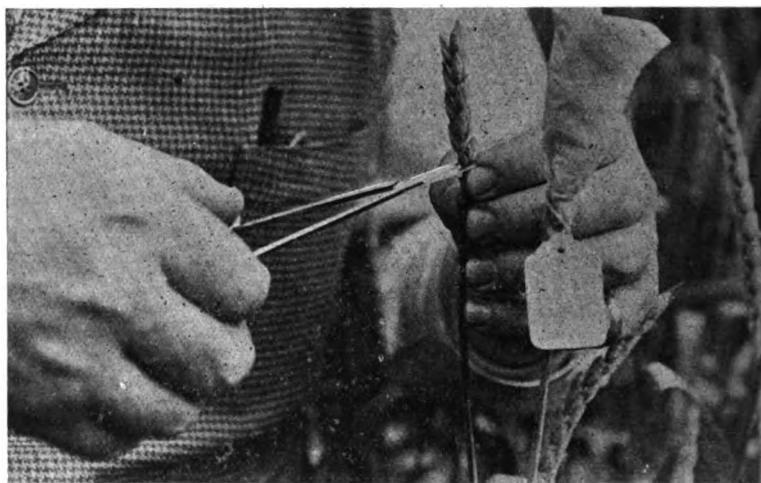


Fig. 280. Removing the flowers of the smaller later spikelets at the base of the spike, leaving only the strongest florets to be supplied with pollen from another plant. In front of the operator's left hand is a spike which has been cross-pollinated, then covered by wrapping about it a piece of tissue paper, which is tied on.

eight in the center of the spike are removed, the small florets in the center of these are also clipped off with sharp pointed dissecting scissors, leaving only the twelve to sixteen strong lower florets of the several spikelets, all being at nearly the same stage of maturity. Care is used to remove all the anthers from every one of these flowers and to so withdraw them by means of sharp pointed tweezers that no pollen is left within the floral envelope. The anthers gradually turn yellow when nearing ripeness. The eye soon becomes experienced in determining, from the partially

changed color, when the floret is nearing the period of fertilization. Florets found so far advanced that there is danger of self-pollination are discarded and removed. The anthers having been removed from all the flowers, the spike is covered with tissue paper. This is wrapped loosely about the spike and tied above and below to prevent the entrance of foreign pollen. In case of flowers which are nearly ripe, pollen is at once applied before covering the flowers. Careful experimentation might show that it would be an economy of time in producing a given number of cross-bred strains to apply pollen at the time of emasculating the flowers and again the next morning, and even a third time early the second morning. However, since each cross-bred kernel is capable of carrying so as to make a number of types, it is not difficult to produce more new varieties than the station has time to develop and test. Pollen from the plant used as the male parent is secured by selecting anthers which are ripe, as shown by their yellow color, and by the ease with which the pollen grains roll out when the pollen sacks are broken.

The operation of removing the anthers and of inserting pollen cannot be shown in detail by means of photographs. The fine points of the tweezers are inserted between the flowering glume



Fig. 281. Opening the floret to remove the anthers.

and the palea, as shown in Fig. 281, and as they are allowed to spring apart the floret is opened, and the anthers removed. Care must be taken to avoid injury to the stigma and to the ovary by opening the floret too wide, or by otherwise using the parts of the floret in a rough manner. The difficulties of removing the anthers are shown in 5 and 4 A in Plate XXV., page 413. To insert pollen the tweezers are again used to open the floret, as in Fig. 282. The pollen is carried into the floret by grasping a ripe anther in the tweezers and inserting it between the two portions of the chaff, care being used that the pollen sacks are open and



Fig. 282. Inserting a ripe anther from the plant used as the male parent into the floret of the plant used as the female parent.

that pollen falls thickly upon the stigma. When ripe the pollen grains no longer adhere to the walls of the pollen sacks but run about as particles of flour. These ripe anthers are taken from the florets on a spike of wheat plucked from the plant used as the male parent. Other plans may be used, as employing a small steel spatula to carry the pollen to the stigma.

Of the flowers handled, the percentage producing seeds has been larger and more of these have proven true crosses when the labor in crossing has been executed with great care. From

five to twenty-five per cent. of the flowers handled produced seeds, and part of these are not true crosses, as shown by their resemblance to the mother plant only, self-pollination having occurred. Those plants resulting from out-crossing which do not show any of the characteristics of the variety used for the male parent are discarded as not being true crosses, though it is recognized that an occasional true cross may so completely resemble the female parent as to not show the male type, at least not in the first two generations.

In making in-crosses it is very important that the emasculating and pollinating be done with care, that all resulting plants may be true crosses, since the parents are similar and there are no means of determining whether there is a true cross or the seed has resulted from self-fecundation.

The nursery number of the plant used as the male parent, as well as the number of the plant to which the pollen is applied, also the date of handling, are placed on a card which is attached to the culm below the crossed head. When ripe both parent plants are harvested and a record made of their yield, so that the history of the "performance record" of the parent plants may be complete. The handled spike is placed in a small envelope, which is placed with the remaining heads of the mother plant in a large envelope.

Each kernel of wheat found in the handled spike becomes a mother plant. The first year it is placed in the nursery with an individual number. The second year a hundred, more or less, of the seeds of each plant of the first generation are planted. Any stocks which do not appear reasonably strong are at once discarded.

Here the method of procedure is as yet an unsettled problem. So far it has been our custom to save only the one best plant from the centgener. It now seems logical to save several, or to save all the strong plants in bulk, grow them in field plots for a few years that they may have time to vary, and then to introduce them into the nursery selection again, using one or two thousand seeds and saving only several of the best resulting plants. Henceforth the selection of the best plants in the nursery and

the multiplication of their seeds take the same course as when varieties are originated by selection alone, as described in a former section.

Crossing Produces Greater Variation among individual plants than is observed where selection alone is followed. The present indications are that the average yield of plants resulting from a cross between distinct varieties is less, at least during the first few generations, than the average yields of the two parents. But there being more variation among the cross-bred stocks, there is greater opportunity for the selection of the occasional good plant which will produce plants yielding better than either parents of the kind. We have abundant proofs of the greater variation of cross-bred stocks.

In Fig. 283 is an illustration of unusual variation resulting from crossing two varieties of wheat. Of the three spikes in the upper row the one at the left is the Fife parent, the one at the right is the Blue Stem parent, and the one in the middle represents the average of the spikes produced in 1894 on plant No. 1874, though there was considerable variation in the several spikes. One hundred seeds were planted in 1895 from this mother plant, and all the variations represented in the middle and lower rows were found. In the progeny of no other cross-bred seed have we seen such a marked tendency to vary. The two varieties of wheat which were crossed never have more than very short awns, while among the progeny are several types with awns of various lengths. The chaff on some of the plants was hairy like the Blue Stem parent, on others smooth like the Fife parent, thus giving proof that a true cross had been made. In form of spike, some resembled one parent and some the other, while numerous spikes were quite different from either in this particular. Thus the second head from the left in the middle row had a square form like the so-called "square-headed" wheats. The second from the left in the lower row has its rachis shortened at the upper end, producing a broad top to the spike, as with the so-called "club wheats." Several of the plants had dark brown chaff, others chaff with a light metallic tinge, each of which are like types of wheat quite distinct from



Fig. 283. In the upper row the right-hand spike is the Blue Stem parent, the left hand one the Pife parent, and the central spike is the average spike of the single plant of the first generation. The spikes in the middle and lower rows are forms which appeared in the 100 plants of the second generation, all of which came from seeds from the single plant of the previous year.

either of the white chaffed parents of this cross. The causes of these variations, the laws governing them, their relation to parental wheats which may have entered into previous crosses of either parental kind, a probability of the continuance of the tendency to vary, and similar questions suggested by these results,—open up many questions for experimentation.

Great variation occurred in strength and also in yield. In the case above mentioned stocks from several plants grown in 1895 were planted in 1896. There was much variation in the strength of the several stocks. In some nearly all the plants were strong, in others most of the plants were weak; and there was great variation in the strength of the plants in the plot. The best plant was chosen from each of the three stocks, and a plot was planted from each of these plants in 1897. From two strongly bearded plants of two of the best stocks of the previous year plots grown in 1897 proved to be very strong, apparently worthy of making into two varieties, though both came from the same cross-bred seed of 1893. A third plot planted in 1897 was from the best plant of a weak stock of the previous year. It had been observed in 1896 that some of the plants from this cross bore but few seeds, and this entire stock was almost sterile. The seeds grown in 1896 generally failed to grow in 1897. Only eight per cent. produced mature plants, and these were weak. This branch of the stock, unlike the two bearded branches, had apparently inherited the tendency to vary strongly in the downward direction, or was a non-fertile hybrid,—a mule.

The two strong stocks were continued in the nursery in 1898, by planting plots from the strongest plants of each, and they again produced plots of vigorous plants, one of them being among the very strongest stocks in the nursery.

This is an extreme case of variation resulting from crossing two varieties which are not closely related, as shown by the hairy chaff of one parent and the smooth chaff of the other. And there are variations towards stronger and towards weaker types. The weaker forms are very easily eliminated by selection. The labor required is to select from among the better forms those which

re the very best. As it now appears, one of the best two stocks will prove superior, but it may require a number of field trials and milling tests to decide which of these wheats is most profitable to grow, or it may be found that one is useful in one part of the state and the other in another part. Such variation is engendered by crossing wheats that from a single kernel a number of useful, yet distinct, varieties of wheat may arise. The production of variations requires only a few minutes or at most a few hours. Years are required to properly select the progeny of a cross-bred stock so as to secure the most useful varieties.

Time Required to Reduce Cross-bred Wheats to a Uniform Type.—Several wheats known to be true crosses have been developed by multiplying the seeds from single mother plants of the second to fourth generation after the cross, and in each case little or no variation has occurred among the plants in the field.

In 1894 a plant was grown from a grain resulting in 1893 from a cross between Blue Stem and Fife parents. The seeds of this plant were placed in the nursery in 1895. Of the resulting plants seventy-two per cent. had hairy chaff like the Blue Stem, and twenty-eight per cent. had smooth chaff like the Fife.

In 1896 seeds from several hairy plants produced plants seventy-six per cent. of which had hairy chaff, and seeds from several of the smooth chaffed plants produced plants eighty-two per cent. of which were smooth chaffed.

In 1897 seeds from hairy chaffed plants of the previous year produced plants of which ninety-eight per cent. were true to type; and of the plants from seeds of smooth chaffed plants ninety-seven per cent. were without hairs on the chaff.

In 1898 of the hairy chaffed type ninety-nine and one-half per cent. and only ninety-one per cent. of the smooth chaffed plants came true to type.

If newly originated cross-bred wheats can be reduced to type in a few years, as is indicated by the facts above mentioned, the making of cross-bred varieties is not difficult from the standpoint of uniformity. In the effort to secure large yields with superior quality, botanical appearances, it would seem, will take care of

themselves. These facts indicate also that individuals chosen for large yield and good quality will continue true to their type in these most important characteristics.

The evidence seems conclusive that better varieties of wheat can be made at an expense which is indeed very small when compared with the increased value of varieties which will raise the average yield per acre even only a part of a bushel.

FIELD MANAGEMENT FOR WHEAT.

The average yield per acre of wheat in Minnesota is several bushels below where it should be maintained, and the quality is as good as is warranted by our exceptional conditions of soil and climate. The cultivation of this crop is not given that attention which its importance in Minnesota farming demands, nor is the intelligence of our farmers should guarantee. In our endeavor to induce farmers to leave off exclusive wheat growing, those who seek to promote better methods of farming are too often berated the crop rather than its abuse; and the methods of cultivating wheat have not been sufficiently emphasized. While wheat farming should be condemned, raising wheat as one of the prominent features of the general farm is worthy of much encouragement.

There are many farmers who cannot profitably bring wheat into their system of farm management. This is especially true of the owners of light sandy lands who cannot afford to grow crops which will remove so much fertility from the farm as wheat. Some dairymen and stock growers can make better use of their land in producing stock food than by growing grain for sale. But most of the farmers of the state can use this crop with profit on a limited portion of their arable fields. Those who have the most live stock can produce the largest and most profitable crops of wheat, and they, having an abundance of manure, can best afford to grow those crops which exhaust the fertility of the fields.

HOW SHALL WE ROTATE CROPS?

Systematic rotation, using some crops to prepare the soil for others, is not so clearly understood, nor its importance so fully

realized, as would be greatly to the advantage of our farm. Our rich soils have led us into profligate and wrong practices in the management of our fields. Rotation is the planting of crops in a regular order of succession, which is repeated from year to year, or in a series of years to another. An example of a simple, short rotation is as follows: Wheat, clover, corn; wheat, clover, corn, etc.

Since the small cereals succeed best after cultivated and green crops, and these crops succeed well after the cereals, there is an advantage in growing these classes of crops in alternation, rather than in planting each continuously upon separate fields. Next to producing profitable crops and to keeping up the fertility of the soil, keeping down weeds is the most important result of rotation of the crops in a given field.

Some of the points which must be considered in planning rotation of crops on the fields of a farm may be enumerated as follows:

1. Devise a plan of rotation, or plans of rotations, which will maintain the fertility of each field and will at the same time give yearly profits from the farm.
2. Devise and make a drawing of a plan of the farm which shall be divided into several permanent fields. Where practical each field should be fenced and connected with the barnyards by a centrally located lane, that each field may be pastured during any portion of year.
3. Where the farm is all arable land it pays best, as a rule in Minnesota, to bring it all under systems of rotation, unless the location of some fields seriously interferes,—none being laid down to grass permanently, nor other portions subjected to growing continuous crops of grain.
4. To retain the larger part of the fertility on the farm, the major part of the land should be planted to coarse forage and concentrated grains to be fed to live stock, growing grain, potatoes, and other exhaustive crops for market on only twenty-five per cent., or less, of the total area.
5. In addition to a good plan of rotating the crops where con-

ass, clover, etc., are used to keep down the weeds, and to keep the fertility for the exhaustive crops, each crop should be planted, cultivated and harvested in the best possible manner.

5. Keep sufficient live stock to consume most of the crops produced; using them to make as large quantities of manure as practicable. This manure should be most carefully saved, and spread rather thinly on the fields, that its greatest effect may be secured.

6. Avoid turning under ripe weed seeds; kill out all noxious weeds, as mustard, quack grass, burdock, thistles, etc., by raising special crops, by bare fallowing, or by attacking each individual weed as the particular kind of weed may require.

7. Grow wheat, flax, barley, oats, potatoes, and other exhaustive crops for sale when they are sufficiently profitable to equal the cash returns for live stock products, and pay also for the decrease they cause in the fertility of the fields.

8. A farm on which one-third of the land is devoted to growing grain, one-third to growing grass, and one-third to growing rough forage for feeding live stock in winter, can be kept up in fertility if part of the grain, as well as all of the forage, is fed on the farm.

9. Too much land in pasture can be avoided by growing corn, sorghum, and other crops for silage or for succulent annual pasturage in midsummer, when pasture grasses are dormant—these crops to be cured and used for dry fodder if ample rainfall results in such a heavy yield of forage in the regular pasture fields that they are not needed for pasturage.

10. A few small fields near the barn are needed on which to grow annual forage for silage, silage or dry fodder, or crops whose roots in alternation with the grains, for which these cleaning crops so thoroughly prepare the soil.

11. Rotation of crops, thoroughly planned, and held to in a systematic though not too rigid manner, brings with it a more orderly arrangement of the farm business, and the farmer works to greater advantage, with clearer purposes, and efforts centered on a longer time on definite objects. His work has greater

cumulative effects. He has larger ultimate objects to work for and has greater interest and pride in his work.

PLANS FOR CROP ROTATION.

In Fig. 284 is given a plan for rotating the crops on a 160-acre nearly level prairie farm. This particular rotation would suit some farms in southern Minnesota, and with minor modifications it would work well on many farms.

Lack of space here will not admit of an extended discussion of how to use this kind of a drawing, with accompanying table for a farm not planned as is this one. Those who are apt in arithmetical and mechanical problems will be able to make similar plans and tables for the future arrangement of their farms and field crops.

This farm is arranged for two sets of fields, one of six fields of twenty acres each, the other of three fields of ten acres each. On the six larger fields there is a six-year rotation. In this rotation corn is followed by wheat, and with the wheat timothy and clover are seeded. If the grass does not grow sufficiently well to make a stand it is plowed under and wheat and grass are again sown. The grass is used for meadow for one or two seasons and the third (or the second and third) year it is used for pasture. Where more convenient some fields may be used for meadow for the two or three years, and other fields may be used for pasture during their periods in grass, though there are advantages in having all the fields fenced so that the aftermath and other shift pastures may be utilized, and so that the grass may be in pasture during the last year. The pasture is followed

Note.—The following convenient classification of pastures and meadows is used:
Permanent Pastures.—Lands which are sown to grasses with a view to using them permanently as pastures.

Rotation Pastures.—Fields on which grasses and clover used for pasture are grown in alternation with grain and cultivated crops under a system of rotation.

Annual Pastures.—Fields on which are grown in the rotation annual crops, such as rye, rape, or corn, which are pastured off.

Shift Pastures.—Second crops, as aftermath on timothy, clover, or other meadows; grain stubble, standing corn stover; grasses used for pasture in the early spring before plowing for fodder corn or other late planted crop; rape or turnips planted among grain and pastured off in autumn; crops injured by hail or otherwise and used for pasture before being plowed down, etc.; etc.

by a small grain crop. Here sufficient oats and barley should be grown for feed. If more grain is grown than can be fed out, wheat or flax may be substituted for a part of the oats or barley during this sixth year. The seventh year the rotation is again begun with a crop of corn.

The rotation shown in Fig. 284 and Table LIX. provides about the right proportion of grain and feed crops for a farm centrally located in the southern half of the state. In the heavy lands of the Red River Valley more small grain might seem wise, and on our thin soils in some sections of the eastern portion of the state less grain would be better. The sketch of the rotation on the farm, together with the tabular statement, is not given as a model so

Table LIX. Showing Crops on Each Field Each Year.

	Corn.	Wheat.	Meadow.	Rotation Pastures.	Annual Pastures.	Oats.	Barley.	Flax.	Mangels.	Potatoes.	Podder Corn.
902.....	A 20	B 20 I 10 E 10	C 20 D 20	G 20	H 10	I 10	.....	.....	F 2	F 1	F 7
903.....	I 20	A 20 H 10 B 20	C 20	D 20	F 10	G 10	.....	G 10	E 2	E 1	E 7
904.....	G 20	I 20 D 10 F 10	B 20 A 20	C 20	E 10	D 10	.....	.....	H 2	H 1	H 7
905.....	D 20	G 20 E 10 I 20	A 20	B 20	H 10	C 10	C 10	.....	F 2	F 1	F 7
906.....	C 20	D 20 H 10	G 20 I 20	A 20	F 10	B 10	B 10	.....	E 2	E 1	E 7
907.....	B 20	C 20 D 20 F 10	G 20	I 20	E 10	A 10	.....	A 10	H 2	H 1	H 7

Note.—The letters in the squares under the columns for each crop indicate the fields, as named in Figs. 284, 285 and 286, and the figures show the acres of the crop planted in the respective fields.

MAJOR ROTATION.—Fields A, B, C, D, G and J.

1. Corn—C. 1. Wheat—W. 2. Meadow—M. 1. Rotation Pasture—
 1. Oats, Barley, Flax or Wheat—O., B., F. or W.

MINOR ROTATION.—Fields E, F and H.

- Wheat—W. Fodder Corn, Roots and Potatoes—F. C., R. and P.
 Annual Pasture—A. P.

Fig. 284.—Rotation of Crops.

20 O., B., F. or W., 1902. C., - - - 1903. W., - - - 1904. M. or W., - - 1905. M., - - - 1906. R. P., - - - 1907. I		A. P., - - - 1902. W., - - - 1903. C. F., R. and P., 1904. A. P., - - - 1905. W., - - - 1906. C. F., R. and P., 1907.
20 R. P., - - - 1902. O., B., F. or W., 1903. C., - - - 1904. W., - - - 1905. M. or W., - - 1906. M., - - - 1907. G	10 C. F., R. and P., 1902. A. P., - - - 1903. W., - - - 1904. C. F., R. and P., 1905. A. P., - - - 1906. W., - - - 1907. F	W., - - - 1902. C. F., R. and P., 1903. A. P., - - - 1904. W., - - - 1905. C. F., R. and P., 1906. A. P., - - - 1907.
20 M., - - - 1902. R. P., - - - 1903. O., B., P. or W., 1904. C., - - - 1905. W., - - - 1906. M. or W., - - 1907. D		M. or W., - - 1902. M., - - - 1903. R. P., - - - 1904. O., B., F. or W., 1905. C., - - - 1906. W., - - - 1907.
20 W., - - - 1902. M. or W., - - 1903. M., - - - 1904. R. P., - - - 1905. O., B., F. or W., 1906. C., - - - 1907. B		C., - - - 1902. W., - - - 1903. M. or W., - - 1904. M., - - - 1905. R. P., - - - 1906. O., B., F. or W., 1907.

Note.—The letters in the lower corners of the several fields of this 160 acre farm are used as names of the respective fields, all of which are fenced; and the figures in the upper corners show the number of acres in the fields. The crops grown in each field for each of six years are shown in the center of the field by the abbreviation which are explained above. As shown here and in Table LIX, the crops are alternated from field to field in such a manner that nearly similar amounts of each crop are grown each year. By adding crops in the same order of succession, the rotation can be continued indefinitely for each field.

much as to illustrate the method of making a working plan which will be on record for reference at any time. At the close of each crop year the plan should be redrawn, if any changes are needed, that they may be inserted in the new plan and in the tabulated statement. Besides this general plan, another plan of the farm should be drawn at the end of each year, giving the actual history of the crops grown the previous year. Such a plan for the year 1902 is shown in Fig. 285.

Fig. 285.—History of Yields of Crops Grown in 1902.

20			10
	Oats 10 @ 48 bu.=480 12 T. Straw	Wheat 10 @ 22 bu.=220 10 T. Straw	Annual Pasture Rye, followed by Corn. Pastured 20 cattle 50 days
I			H
20		10	10
	Rotation Pasture Pastured 3 colts and 20 cattle 80 days	Fodder Corn 7 35 Tons ----- Mangels 2 30 Tons ----- Potatoes 1 150 bu.	Wheat 4 @ 24 bu.=240 10½ T. Straw
G		F	E
20			20
	Meadow ¾ Timothy, ¼ Clover, 14½ Tons Hay Pastured 20 cattle and 3 colts 28 days on second crop	Meadow ¾ Timothy, ¾ Clover 2 T. 1st Crop ¾ T. 2d Crop	
D			C
20			20
	Wheat 22 bu.=440 bu. 18 T. Straw	Corn 45 bu. per a.=900 bu. 30 T. Stover	
B			A

Note.—Fig. 285 shows a plan of recording the history of the crops on each field for a given year. Such a history for each of ten years would be very interesting and valuable as an aid to further plan the farm and field management.

of the minor rotation may become too rich for crops of wheat, if manured every third year, and since the larger fields will take care of more manure, it may be best occasionally to manure these smaller fields only once every second course, or every sixth year. Spreading the annual accumulation of manure out over twenty or thirty acres of ground will insure that no piece of land be at any time too heavily manured for wheat, even though it be heavy land. On our richer lands ten tons of manure per acre applied to a corn crop grown preparatory to growing a crop of wheat is better than more. In other words, we get more benefit to wheat from manure if spread thinly than if applied to a lesser amount of land. And this is also true regarding the crop of corn or roots which should be grown between the manuring and a crop of wheat. It will be observed in manuring on the minor rotation fields that a cultivated crop or a crop of annual pasturage is grown after the manure is applied before the wheat is planted. While wheat receives a benefit from a direct application of stable manure from being better nourished, it also receives an injury which often more than counter-balances the benefit. Its growth of leaves, stems and roots is made too strong in the early part of the season, and the overgrown plants produce comparatively little seed of poor quality. The less active residue of the manure when wheat follows a crop of corn to which manure was applied greatly benefits the wheat without injuring it, and in the interim the corn will have taken most valuable toll from the manure. Unlike the wheat, corn gets great good and rarely any injury from freshly applied barnyard manure.

Fig. 287 shows a 160-acre farm with most of its fields growing grain continuously, while on a comparatively small portion of the land near the buildings permanent pastures and meadows are maintained.

There is a most serious loss in two ways. The permanent pastures in our climate, subject as it is to summer droughts, do not yield well; not so well as rotation pastures. But worse than this is the loss from poor crops of grain on the remainder of the farm. These outer fields need the beneficial influence of being

occasionally seeded to grass, and the fields now used for pasture would produce excellent grain. More land should be in grass, less should be in grain, and more stock should be kept as a means of retaining and even increasing the supply of available plant food in the fields. The difference of profit under the two systems of field and farm management is brought out in the next section.

Wheat Farming vs. Wheat on the General Farm.—The history of all Minnesota counties which have been settled for twenty years or longer is similar in that good crops of wheat were pro-

Fig. 287.—A Poorly Planned Farm.

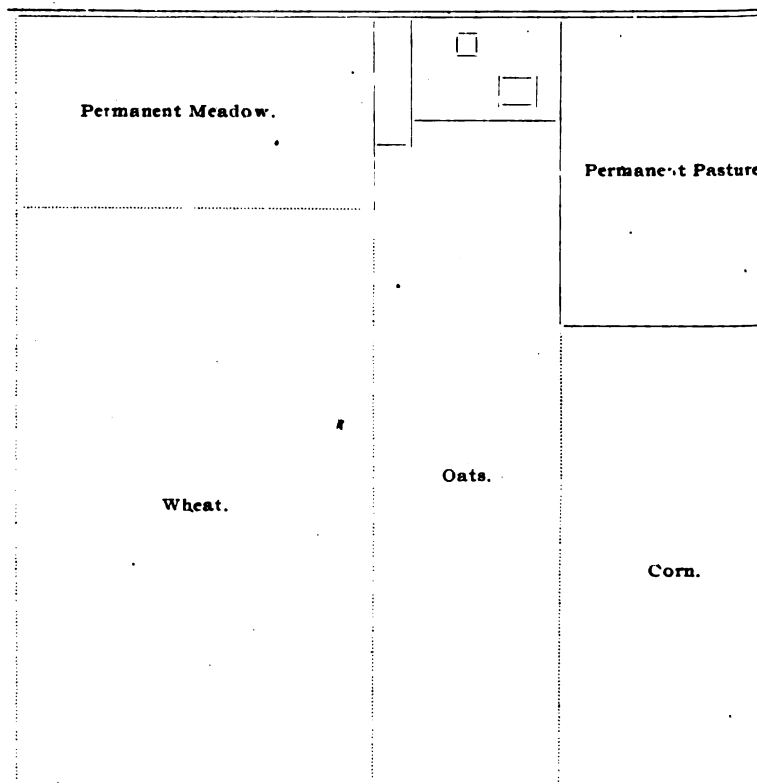


Fig. 287. A poor rotation on a grain farm of 160 acres. The only rotation is to change the wheat with the oats and corn, alternate years. Dotted lines mark fields and solid lines mark fences.

duced for a period of ten to twenty years, but sooner or later there was a decline in yield and in quality. There was an occasional good crop, but the yields and grades become more irregular and unsatisfactory. The comparatively low average yield per acre, with the prevailing low prices, resulted in small profits to the farmers. This decline in wheat crops has been observed in all parts of the state; earlier in southeastern counties and during recent years in the western and northwestern counties. And adjacent states have had the same experience. Some of the causes can be enumerated, only part of which operate in any one district in any given year. Prominent among these causes of reduced crops of wheat may be mentioned rust, weeds, chinch bugs and smut.

On the other hand, farmers and communities which have introduced large numbers of domestic animals into their plan of farm management and have practiced rotation in their field crops, with wheat as only one of the principal diversities, have met with much better financial success. This fact has come to be generally recognized and the proof has recently been placed on a mathematical footing by means of statistics gathered by Mr. L. G. Powers, then State Commissioner of Labor. From the records of mortgage foreclosure sales in the wheat growing counties, and also in counties where wheat is only one of several products, among which live-stock and dairy commodities are prominent,

TABLE LX.—Proportion of Mortgage Foreclosure Sales for 18 years in the State, in Wheat Counties, in Counties where Diversified Farming is Practised and in Suburban Districts.

YEARS	Entire State 1 to	Average	Fifth District Hen'pin Co. 1 to	Average	Stock and Dairy counties 1 to	Average	Wheat counties 1 to	Average
1880-1	135	151	299	314	108	108	183	95
1884-5	180		329		198		23	
1886-7	167		243		306		107	
1890-1	144		166		295		94	
1892-3	200		171		396		141	
1894-5	130	94	98	94	352	356	81	98
1896-7	153		89		320		115	
Average	151		199		282		115	

he has collected the average mortgage foreclosure sales showing that wheat farming has not been so profitable as diversified farming. In Table LX. are given his summaries showing the relative mortgage foreclosure sales in the two classes of counties. The summaries are given for biennial periods and extend through eighteen years. The left-hand column of figures shows that in the entire state there was sold under mortgage foreclosures one acre to every hundred fifty-one acres of assessed lands, the range being from one acre in one hundred and thirty to one in two hundred acres.

In the right-hand column, showing the proportion of mortgage foreclosure sales in the wheat-raising counties of the western and northwestern parts of the state, the average rises to one acre sold under mortgage to every one hundred and fifteen acres assessed; the range for the biennial periods being from one in eighty-one to one in one hundred and eighty-three. The latter is for the biennial period of 1880-1, at which time comparatively few of the many mortgages, then newly made, had fallen due. During the last fifteen years the condition of the farming business in this "wheat belt" had not become better nor particularly worse. The mortgage foreclosure sales of farm lands averaged about one-fourth more than for the entire state.

In the next to the right-hand column are figures representing the proportion of mortgage foreclosure sales in the southeastern corner of the state. Here, at the beginning of the period covered by the statistics, wheat was still grown in large quantities, and the proportion of land sold under mortgage to the total on the assessment rolls was one to one hundred and eight. Very soon after this the farmers began to increase their herds, to raise timothy and clover seed instead of wheat, to grow corn for stock and to develop co-operative dairying. The effect on their prosperity was immediate and lasting. The figures in the table show that the mortgage foreclosure sales soon ran down to about one-fourth the former proportion, and the local bankers testify that the farmers became lenders rather than borrowers of money. It is not too much to say that still better systems of field and farm

management could be practiced which would add as much more to the prosperity as has the change from grain farming to general farming. Better farming has already been entered upon, and really good farming is sure to come at an early date.

In marked contrast to the prosperity of the farmers in the district where general farming has gotten a fair foothold is the condition of land speculators near the large centers of population. Mr. Powers has tabulated the averages for the Fifth Congressional district, which is composed of Hennepin county, in which are located the city of Minneapolis and the summer resorts about Lake Minnetonka. The figures are given in the center of the table. The mortgage foreclosure sales here increased about as they had decreased in the southeastern counties. Doubtless in the Fifth district the mortgage foreclosures were largely due to the payment of speculative prices for lands near the city or near the lake. When the hard times came the large debts could not be carried, and the speculators lost the lands.

In conclusion Mr. Powers says substantially as follows: The agricultural department of the State University and its various experiment stations have rendered the farmers of the state great assistance in ascertaining by experiments and investigations what lines of farming can profitably be pursued in the various sections of the state, and the conditions under which such profit can most fully be attained. In this way the school-house and its students prove potent agencies in ameliorating bad financial conditions.

Causes of Poor Profits in Wheat Farming.—The several causes which lead to poor profits from raising little else than wheat are not as yet well understood. Some factors may be enumerated as follows: (1) In raising wheat after wheat the land is left in poor mechanical condition for wheat; (2) the store of available plant food is gradually reduced; (3) the humus of the soil is reduced to a low point; (4) weeds become numerous; (5) chinch bugs and some other insects thrive on land kept continuous in a crop on which they feed; (6) rust is present

in quantities to overwhelm the plants of wheat; (7) poor methods of managing the soil and crop too often are faults of the wheat farmer; (8) wheat raising provides profitable employment for farm labor for only a part of the year; (9) planting a large acreage to small grains requires much labor at given seasons of the year, and crowds out other crops and enterprises which, if started, would give profitable employment at seasons when the wheat, oats, barley, and flax require no labor; (10) wheat farming leads to the wasteful expenditure of money in poorly preserved farm machinery; (11) raising small grains, as practiced, calls into action less intelligence and gives less individual employment to the farmer, his wife and his children, than comes from carrying on the more complex, yet more enjoyable occupation of general farming with live stock, wheat, and other specialties; (12) grain farming does not build up the wealth of the community so rapidly as general farming; (a) there is less permanent farm investments, as fertility, buildings, fence, etc.; (b) there is less development of villages and towns in merchandising, manufacturing and financial establishments; (13) the community of interests is far less in the grain farming community than among people who raise stock, vegetables, fruit, etc., along with grain.

WHEAT IN ROTATION PAYS WELL.

Wheat, if properly grown, is by all means our most profitable grain crop, and easily stands at the head of all Minnesota products in the amount of money it brings. In 1898 the income to the state from the wheat produced approximated fifty millions of dollars, while the dairy products brought about twenty millions of dollars.

While we have been promoting other lines of farming than the large acreage of wheat might in part give way to other crops, we have given too little attention to methods of making the wheat we should raise pay us better profits per acre. This has been in part due to the great difficulties met, and the long time

quired in determining questions of field practice. Manufacturers of machinery have done very much to improve the methods of planting and harvesting wheat, but methods of farming calculated to prepare fields for wheat are wrought out but slowly. The North Dakota Experiment Station has shown that where wheat after wheat in the Red River Valley yields only moderate crops, wheat after corn or other cultivated crops, or wheat after clover, yields very good crops. In the older sections of the state many farmers who for a time left off raising wheat have again commenced this among the crops raised in the rotation. Ohio, Pennsylvania, New Jersey, and other eastern states, where the surplus of fertility has been exhausted and commercial fertilizers must be purchased, are raising considerable wheat even with present low prices. The strong reasons for continuing this crop in the rotation are there appreciated. As our southeastern counties swing from the extreme of all grain to no wheat, a medium amount is found and a limited acreage of wheat is grown. The advantage of using previous crops to prepare the land for good wheat crops has been most clearly demonstrated by the North Dakota Experiment Station. From a report made by Prof. John H. Shepperd, in the Eighth Annual Report of that station, the six following tables have been compiled:

TABLE LXI.—Wheat Continuously.

PLOT	1892	1893	1894	1895	1896	1897
.....	21.5	8.2	20.0	24.0	16.1	13.1
.....	19.8	10.0	21.9	23.0	17.9	15.0
.....	21.1	8.1	20.3	22.5	15.8	17.8
.....	20.0	11.8	22.6	24.5	16.4	18.2
.....	19.4	8.6	18.3	23.5	19.5	14.5
.....	17.3	9.5	15.5	23.0	11.4	10.3
Range of 6 plots.....	19.8	9.4	19.7	23.4	16.2	14.8
General Average.....						17.2

In Table LXI. are given the yields of wheat for 1892 to 1897, inclusive, of six plots on which wheat had been grown continuously for several previous years.

TABLE LXII.—Wheat after Fallow.

PLOT	1892	1895	1894
4.....	Bare fallow.	11.8	23.8
15.....	Bare fallow.	16.0	25.8
20.....	Bare fallow.	19.6	25.6
26.....	Bare fallow.	14.1	21.0
Average 4 plots.....		15.4	24.0
General Average.....			19.7

In Table LXII. the record is given of the yields of wheat 1893 and 1894 on plots on which the continuous wheat cropping was avoided by a bare fallow in 1892.

TABLE LXIII.—Wheat After Cultivated Crop.

PLOT	1892	1893	1894
5.....	Corn 38 bu.	14.4	25.0
6.....	Corn 37 bu.	17.2	24.8
12.....	Rape 5½ T.	19.6	26.3
13.....	Mangels 7½ T.	18.5	26.3
Average of 4 Plots.....		17.4	25.6
General Average.....			21.5

In Table LXIII. are given the yields of wheat for 1893 and 1894 on plots on which corn, rape or potatoes were cultivated 1892.

TABLE LXIV.—Wheat After Barley, Oats, Spring Rye.

PLOT	1892	1893	1894
21.....	Spring Rye 13.2	10.6	18.5
22.....	Barley 29 bu.	6.4	18.5
23.....	Oats 75 bu.	10.1	18.0
Average of 3 Plots.....		9.0	18.3
General Average.....			13.7

In Table LXIV. are found the yields of wheat in 1893 and 1894 on plots which grew crops of barley, oats, or spring rye 1892.

Table LXV. *Field of Wheat in Rotations. Bushels per Acre.*

	No. of Trials	1892.	1893.	1894.	Average for 2 years, 1893 and 1894.	Av. Gain or Loss 1893.	Av. Gain or Loss 1894.	Av. Gain or Loss for Two Years.
Wheat continuously	6	19.8	9.4	19.7	14.5	.....	.....	.....
Wheat after Fallow	4	fallow	15.4	24.0	19.7	+6.0	+4.3	+5.2
Wheat after Cultivated Crops	4	{cult. crops}	17.4	25.6	21.5	+8.0	+5.9	+7.0
Wheat after Oats, Barley and Spring Rye	3	{oats barley and rye.}	9.0	18.3	18.3	-0.4	-1.4	-0.9

In Table LXV. are collected the averages of all the four tables mentioned. Here we are able to compare the yields of wheat under continuous cropping; following the bare fallow, twice plowed; following crops of corn, potatoes or rape kept clean from weeds by thorough tillage; and following the other spring crops, oats, barley, and spring rye.

The difference in average yield for the first year after the alternating crop is shown in the seventh column. There is an increased yield on the fallow land of six bushels per acre; and of eight bushels on the land on which crops were cultivated. On the land on which oats were grown the previous year, there was raised four-tenths of a bushel less of wheat in 1893 than on the land which had been in wheat continuously. The second year following the fallow, column eight shows the increased yield to have been four and three-tenths bushels; and following cultivated crops there was an increase of five and nine-tenths bushels; while following oats, barley and spring rye there was again a decreased yield.

In column 9 the average increased or lessened yields for the two years are given. It should be here noted that the third year there was but little increased yield on the plots which had been fallowed or had borne a different crop in 1892. The good effect lasted only to the first and second years.

Table LXVI. Yield of Wheat after Rotation Meadow. Bushels per A.

Plot.	1892.	1893	1894.	1895.	1896.	A. V. Result 2 years '95 and '96.	Gain 1895.	Gain 1896.
16	19.6	Clo. & T. Hay 2070	Clo. & T. Hay 3225	31	20.5	25.8	7.6	4.3
Av. 6 Plots Wheat Contin- uously.....	19.8	9.4	19.7	23.4	16.2	19.8	.....	.....

In Table LXVI. we have in comparison with the plots growing wheat continuously a plot which had been in timothy and clover meadow for two years. Here the average increased yield was six bushels per acre.

The record of this experiment is of great value. In 1893 and 1894, on land which had grown wheat continuously for ten years twelve plots of wheat yielded an average of fourteen and five tenths bushels of grain per acre. This is about the average yield of large sections of our state. By bare fallowing one year the yields of wheat were increased four to six bushels per acre for the two succeeding years. By growing a crop of corn, potatoes, rape, or by sowing clover and timothy, the yields were increased six to eight bushels per acre. Broadly stated this experiment shows that the yields per acre on our wheat farms will be increased thirty to fifty per cent. by alternating wheat with other crops. This necessitates growing in rotation with the wheat those crops which can be marketed only through the medium of live stock. It means that to make profits out of wheat we must produce wheat as one of several farm products. We must use stock and the crops which they consume to help grow wheat.

PREPARING CORN LAND FOR WHEAT.

The first and most important consideration in preparing land for wheat following corn or other hoed crop is that the cultivation be so thorough as to leave the land free of weeds. The recent development of the corn harvester, and a better selection of varieties of corn for each locality, have started a new impetus in corn growing. Corn for fodder and corn for ears and stover are rapidly invading the wheat districts, increasing the live stock interests, aiding in raising wheat, and yet by means of live stock aiding in retaining the fertility of the land. The front line of the corn belt has moved northward fifty miles within several years, and it is traveling more rapidly than ever.

As a matter of necessity, weedy corn land must be fall-plowed or spring-plowed for wheat; but as a rule, in most sections of Minnesota, the corn stubble which has been kept clean of weeds should not be cross-plowed. That wheat does well after corn without plowing is a matter of common experience in all parts of the state. In case the corn stubble is fall or spring plowed, the soil is made loose to the depth of several inches. Where the seed is sowed broadcast without plowing and covered with the disk harrow, smoothing with the Scotch harrow, only the upper half of the furrow slice is made loose and open. The lower portion of the furrow slice, having become compact since it was plowed a year before for the corn crop, has become thoroughly connected with the capillary moisture below. The top of the moist soil—the moisture line—does not remain at the bottom of the furrow slice, as in case of the replowed land, but rises part way through the furrow slice, and stops at the bottom of the layer of earth made loose by the disk harrow. This lower half or two-thirds of the furrow slice is the richest part of the soil. It contains not only much of the manure which has been applied, but plant food which has risen with the upward flow of the capillary water, and which has been deposited with the vaporation of the water from the surface of the soil. It makes

a difference with the crop whether the plant finds sufficient water in the lower part of the furrow slice to allow it to gather food there, or whether it must find all its nourishment in the subsoil.

PREPARING THE SOIL FOR THE SEED.

In most instances spring wheat should be planted in Minnesota very soon after the frost has left the surface soil. To turn corn stubble or grass land should be plowed in the fall; and corn stubble or potato land should be cleaned of stalks or other rubbish, and where practicable pulverized in the autumn. Where grass and clover seeds are to be sown with the wheat crop, it is especially important that the wheat and accompanying seeds be sown while the soil is moist and cool, that there may be a better chance of securing a catch of grass. Failure to get a stand of grass occurs less frequently when the wheat is sown after corn than after most other crops.

Corn stubble should be broken down to the ground when the soil is frozen. For this purpose a heavy square timber or a road iron drawn by hitching one or two horses to either end can be utilized. Cornstalk cutters are in some cases useful, but a sharp disk harrow often makes it unnecessary to use a stalk cutter, even where the corn was husked from the standing stalks. In some cases it will be wise to thoroughly pulverize corn stubble land before seeding, so that a drill may be used to advantage. In other cases the better plan is to sow the wheat broadcast and cover with the disk harrow, the corn cultivator, or other implement which will turn the soil up to the depth of two or three inches. In case a farmer has only a shoe drill, that implement may be successfully used instead of the broadcast seed where the disk is to follow the sowing. By drilling the wheat shallow, it is so placed that it will be turned under by the disk or other cultivator. Any good method which plants the wheat at the proper depth and leaves the surface soil level and smooth will succeed.

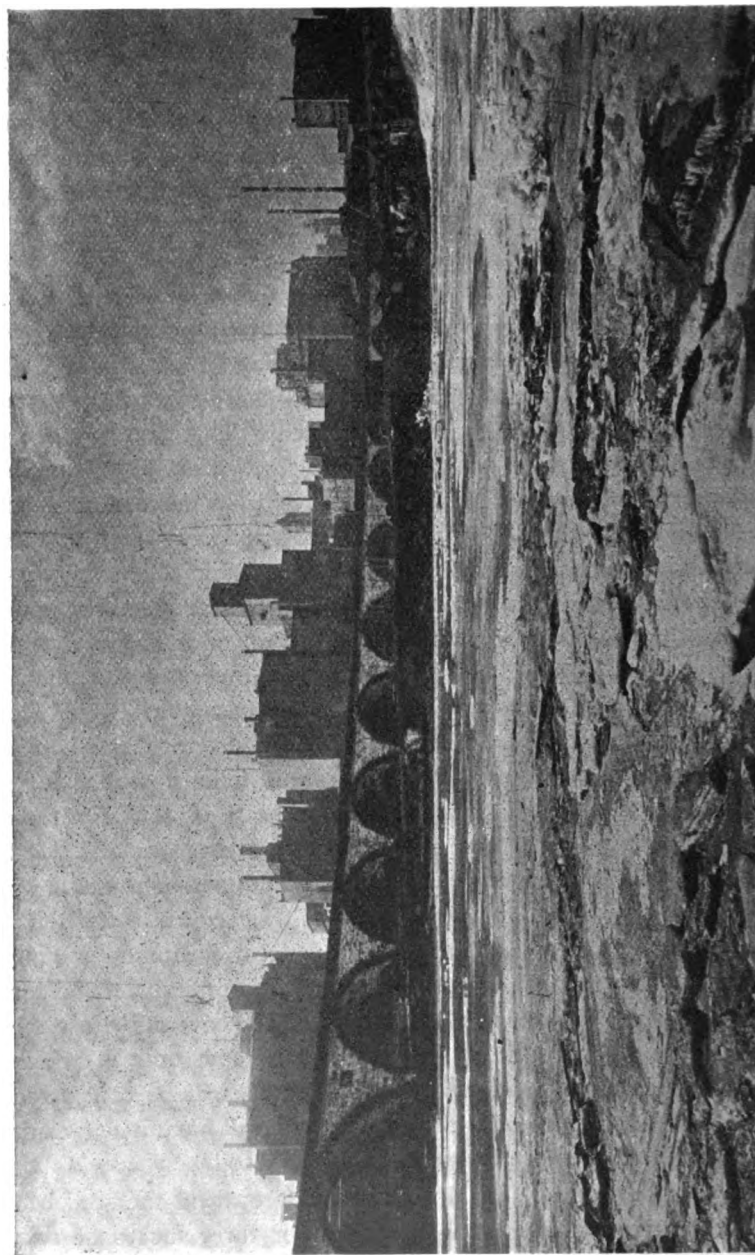
Grass sod should be fall-plowed for wheat. Early plowing

often the better for timothy, while in case there is growing a heavy second crop of clover it is wiser to defer the plowing until a crop can be removed or until it has developed a large tonnage of green manure. The crop is worth more for feed than for green manure, if there is at hand profitable live stock to make use of it, since the manure can largely be returned to the land. Grass makes a good preparation for wheat; while the atmospheric nitrogen added by the clover to those soils which have been depleted of this fertilizing substance often increases the following crop of grain several bushels per acre.

Stubble land after small grain crops is of necessity, or of choice, very much used for crops of wheat. This land cannot be gotten into good mechanical condition for wheat. The stubble and weeds are coarse, do not quickly decay into humus, and tend to make the furrow slice too loose for capillary water to rise into it, and too open, allowing too free circulation of air. Wherever practicable, in a climate which is subject to periods of drought, and in which grain crops are planted continuously, it pays to burn the stubble and weeds. The fire destroys many weed seeds, and destroys the coarse materials which would do more harm than good. The extra cost of making less than a ton of barnyard manure to take the place of the humus-making stubble and of the nitrogen lost in burning is far less than the loss arising from coarse stubble in the furrow slice and weed seeds in the soil. Burning the stubble and not making manure by keeping live stock is, however, undoubtedly harmful to the soil.

But, taking into consideration all things, early autumn plowing is the most important point in the preparation of stubble land for wheat. By early plowing many weeds will be covered before the seeds have ripened, the stubble will have some time in which to become softened and rotted, and the soil will be compacted through the influence of the fall rains, and will have its capillary connections made more intimate with the subsoil.

In the spring care should be taken in preparing the seed bed to thoroughly pulverize the upper two or three inches of soil. Where the winds are not likely to cause the soil to drift, it is



wise to make the surface fine and smooth. Where drifting occurs it is necessary to leave the seed bed coarser, and especially to avoid using the roller, or the plank or "floater".

KIND OF SEED TO SOW AND AMOUNT.

Our extensive studies of wheat raising has emphasized the importance of Blue Stem and Red Fife wheat. Our farmers are occasionally urged by grain men and others to market the stock of Blue Stem or Fife wheat they have on hand and get fresh seed from "the prairie" or from "timber land," or from "clay soil," or in a word from conditions in some way radically differing from those on their own farm. This is not good policy, because, so far as known, it has not been generally proved. We feel certain that too much importance has heretofore been attached to changing seed wheat. Prof. C. A. Zavits, of the Ontario Agricultural College, has recently published experiments which demonstrate that wheat is improved if kept long on the same farm and the seed is yearly subjected to careful bulk selection. The point of far greater importance is to get a wheat of known good quality and with a record for successive large yields per acre in the same general vicinity. Changing seed merely to make a change has dangers as well as advantages. The danger of getting wheat which will not yield well under conditions new to it gives need of the greatest precaution, and next in importance is the care to avoid bringing new weeds upon the farm. A third source of danger is in the introduction of stinking smut. A very good general rule when a change of seed is deemed necessary is to procure the seed of some reliable and neat farmer within the neighborhood, or within a day's drive. By careful inquiry as to the presence of wild oats, mustard, Russian thistles, and other noxious weeds, also smuts, and by carefully inspecting the wheat in the bin, or by sample, the purchaser can avoid introducing these weeds and smut upon his farm. The statements of a trustworthy farmer regarding the yields and grades he has secured for a series of years should have much to do in

determining whether his seed wheat is the variety wanted. A few to several bushels of a superior variety of wheat purchased of the experiment station, of a seed dealer, or of some careful farmer, will quickly multiply into all the seed needed for the entire farm. The amount of seed to sow varies between one bushel and one and one-half bushels for sowing early in the spring. In a season which opens up early, with ample moisture in the soil in a cool spring, with a rich, well compacted furrow slice, one bushel of perfectly sound seed planted in a fine seed bed with a shoe or hoe drill will furnish a sufficient number of plants to stool out and make the necessary thick stand of wheat. Where the conditions are less favorable for "stooling out," a larger number of seeds is required. If the soil be loose, open and droughty, if the season opens up late, if the planting is delayed so that the cool, moist stooling period is mostly passed before the wheat will be far enough developed to branch out, or if other conditions are present to prevent the wheat thickening up,—more seed should be planted. One and one-fourth bushels per acre is usually the best amount to sow where the drill is used. Where the wheat is sown broadcast about a peck more of seed is required.

DEPTH AND METHOD OF PLANTING.

The Depth to Sow Wheat varies between one inch and three and one-half inches. Where the soil is firm underneath and mealy on the surface, two inches is about the proper depth to run the drill shoes or hoes. Where the ground is compact and moist, and the seed is planted in the first part of an early spring, quite as good results will doubtless come from planting only a half inch deep. The wheat plant does well to start near the surface of the soil and to spread its roots in the upper portion of cool moist earth. On the other hand, the young plants can come up through three inches or more of very loose earth, and as the season advances, where the soil is more open and droughty, there is need for planting to a greater depth, that the seeds may be able to get moisture to start germination, and that the roots may a

once enter into moist soil where they can secure plant food as soon as the leaves have expanded sufficiently to use it.

The seeds should be planted as evenly in depth as is practicable, especially if in a drougthy soil, so as to insure that all germinate together promptly. The chains following the shoes of the shoe drill help to cover the grain. The common Scotch harrow is a great aid in smoothing down after cultivating in broadcasted grain, and after the hoe drill, and in most cases it should follow even the shoe drill. The exceptions are in cases where further pulverizing with the harrow would result in the soil drifting worse before the wind. The press wheel following the shoe of the shoe drill, as the wheel of the modern two-horse corn planter follows the shoe of that machine, is useful under some conditions. Press wheels cause heavier draft on the team, make the drill somewhat more complicated and therefore difficult to handle, and have no advantage on heavy moist soils where wheat is planted early in the spring on well prepared land, and are not well adapted to planting wheat on corn stubble ground. They have, however, a wide field of usefulness. Where the conditions are such that the seeds and young plants are subjected to a lack of moisture in the early spring, the press wheel adds to the yield of grain. Where the grain is placed on light soils, especially if planted late, the press wheel compacts the soil about the seeds, just as in planting corn with the hoe we tread on every hill, or just as we tread the loose earth about the roots of a newly planted tree. Farmers in western counties, and those who have light open soils, find press shoe drills very useful, as do the farmers west of the eastern tiers of counties in the Dakotas, where the rainfall is often scant in the springtime.

It often pays to thoroughly harrow the ground two or more times immediately after the grain is sown, so as to make the seed bed more compact below and fine and mellow at the surface. Experiments we have conducted prove that harrowing the grain after it has come up is dangerous, and has caused injury in a number of cases. It lessened the yield in proportion to the amount and lateness of the harrowing. The benefit coming from

the destruction of weeds among the young wheat was more than counter-balanced by the injury the harrow teeth did the wheat plants. More experiments are needed to determine the amount of harrowing best to do after wheat is planted, and the length of time it may be continued. But at present we are inclined to advise care in using even light harrows to kill weeds among wheat, oats, or barley when it is a few inches high. The preparation of the soil should be so thorough that only a small amount of harrowing shall be needed after the crop is planted.

Little can be done for good crops of wheat during its growth except to pull out by hand mustard, lamb's quarters, thistles, and other large growing weeds which would mature their seeds before harvest or would interfere with harvesting and handling the grain. Very poor, weedy crops of wheat had often better be plowed under before harvest time. Expense for harvesting is thus avoided, and the land is fallow-plowed for the succeeding crop. Where pasturage is needed the crop can be pastured during the time the plowing down is in progress. Or the crop can be mowed for hay when in the flowering stage, or a little later. This gives opportunity to plow the field before harvest, and thus prevent most of the weeds from ripening their seeds.

HARVESTING AND STORING WHEAT.

A discussion of the general practice of harvesting the crop, storing the bundles and threshing, storing and marketing the grain must be kept for future bulletins. A few matters, however, in connection with varieties and with the quality of grain for market and for seed cannot well be passed by.

1. Wheat makes the best flour if allowed to become mature before it is cut.
2. The loss of quantity from shelling is great if the wheat is allowed to become over-ripe before reaping.
3. Blue Stem wheat, owing to its open chaff, shells worse than most other varieties of wheat, and therefore it is more important that it be harvested as soon as ripe, and there is more excuse where this variety is grown, for beginning the harvest early.

4. Wheat should be well shocked in round shocks, twelve to eighteen bundles in a shock, set compactly and covered with two good cap bundles, which should be replaced as often as blown off.

5. Wheat should be stacked or threshed as soon as practicable after the shocks have become sufficiently dry. Stacking is rapidly replacing shock threshing, and this change should continue. Better quality in the wheat, and a greater acreage of early fall plowing, will amply repay for the additional expense, and the threshing can be more economically done.

6. Blue Stem wheat is more easily injured while it is in the shock than other varieties, because its chaff does not fold snugly about the berry, permitting rains, dews, sun, and wind alternately to affect it, making the bran more brittle and lighter in color. Therefore it is especially important that this variety be well shocked and that the shocks be capped, even in our windiest, driest counties; and that it should be stacked. Where its bran and color are perfectly preserved Blue Stem grades as high as Fife wheat.

7. Great care should be used in stacking and storing grain which is to be used for seed, that injury to the germinating qualities, by moisture or by heating in the stack or bin, may be entirely avoided.

8. Thoroughly cleaning the wheat which is to be used for seed is of the utmost importance. Small and shriveled kernels of wheat as well as all kinds of weed seeds should be removed. In fanning the wheat a strong wind blast should be used as the heavy, hard kernels are the ones desired for seed. Where one has only a small quantity of very choice wheat for propagation, hand picking will often be advisable to remove barley, rye, oats or other grains which cannot be removed by machinery and which will detract from the value of the wheat when ready for sale for seed.

9. Seed wheat, as well as seed corn, should be tested, as in earth in the house, in a place not too warm, that its germinating ability may be determined. Where wheat shows below ninety-five per cent. germination it should be most thoroughly

cleaned and more than the ordinary amount of seed used per acre, or if very poor it should be discarded.

10. Wheat for seed should be sold and bought on the strictest honor for trueness to name and variety, for freedom from weeds, seeds and smut, and upon personal inspection in the field or bin or at least by sample.

11. The farmer who desires a reputation for growing good seeds which will prove useful to his neighbors must have good land. By means of live stock and the crops they use he must keep the land free of foul weeds, and he must be a good seedsmen, always selling seeds of good quality, and thoroughly cleaned and graded.

The writers take pleasure in expressing their thanks to the many students and helpers, and to others, who have aided in the experiments in testing varieties and in breeding wheat. Messrs. C. P. Bull and A. S. Williams, and Miss Mary Cheeney have aided in preparing the illustrations; Messrs. Warren W. Perdergast, L. B. Bassett, C. S. Scofield, and C. P. Bull, students in the college of agriculture, have assisted in working out the plans of recording the notes in the field crop nursery. Numerous students and laborers have attended to the details with most praiseworthy interest and care.

Our thanks are also due Prof. J. H. Shepperd, of the North Dakota Experiment Station, Prof. E. C. Chillcott, of the South Dakota Experiment Station, and Prof. James Atkinson, of the Iowa Experiment Station; also Superintendents T. A. Hoverstad and H. H. Chapman, of our substations, for their assistance in testing numerous varieties of wheat at their respective stations.

The forbearance of the governing board and of the public in awaiting results from this line of experiments is here acknowledged, and the belief is expressed that in the future the benefit will accrue more rapidly both in superior varieties and in a better knowledge of wheat improvement.

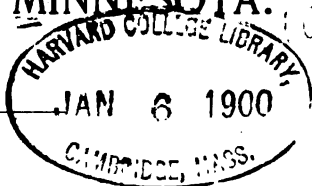
SUMMARY OF CONCLUSIONS.

1. Satisfactory methods of field, milling, and baking tests of varieties of wheat have been devised.
2. Among several hundred varieties of wheat tried by the experiment station, Blue Stem and Red Fife are best for Minnesota.
3. Wheat breeding is outlined, with record blanks and methods of hybridizing illustrated, and the plan of disseminating new varieties is given.
4. Wheat flowers open very early in the morning, and are generally self-pollinated.
5. Immense value is wrapped up in that kernel of wheat which when multiplied into a variety adds a bushel per acre.
6. Kernels from which are produced large yielding plants, good nursery plots, and superior field plots, become mothers of improved commercial varieties.
7. Wheat plants, especially hybrids, vary greatly in yield, in grade or quality, in rust resistance, and in other characteristics.
8. By systematic selection of bulk or hybridized wheats, improved varieties are originated at slight cost as compared with their value.
9. Three out of thirty varieties first originated by selection are being disseminated, and several new hybrids are very promising.
10. The relation between breeding plants and breeding animals is pointed out, and useful deductions are drawn.
11. Many unsolved problems are suggested, and the importance of further study in breed and variety formation is emphasized.
12. Wheat farming has paid, but not so well as general farming where most of the crops are fed to live stock. Wheat should be grown on only a small part of the land, where yields will be large.
13. Field and farm management can be reduced to a system under which profits can be made and the farm become more fertile.



Fig. 289.—Harvesting Wheat on a Bonanza Farm.

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UNIVERSITY OF MINNESOTA.



gricultural Experiment Station.

BULLETIN NO. 63.

CHEMICAL DIVISION.

JULY, 1899.

**MISCELLANEOUS ANALYSES.
COMPOSITION OF TOMATOES.
PROTEIDS OF WHEAT FLOUR.**

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

MCGILL-WARNER CO., PRINTERS, ST. PAUL.

UNIVERSITY OF MINNESOTA.

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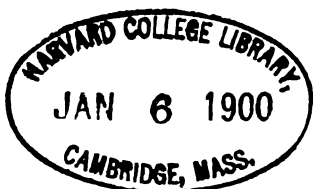
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*From
The University*

MISCELLANEOUS CHEMICAL ANALYSES.

HARRY SNYDER.

The first part of this bulletin contains the results of analyses of various agricultural products and other materials sent by farmers of this state to the Agricultural Experiment Station for chemical analysis. The act of congress creating experiment stations has limited the work of the stations to strictly agricultural lines; hence free analyses cannot be made of minerals, ores, or mineral waters, or work undertaken for individuals or corporations that is of merely a personal nature. Free analyses are, however, made for the farmers of the state of all agricultural products or materials, when the work is of such a nature that the results are of general public value. Questions relating to the sanitary condition of water should be directed to the State Board of Health; those relating to minerals to the University, School of Mines; and those relating to the adulteration of food and dairy products to the State Dairy and Food Commission.

OIL MEAL.

Occasionally complaints are received from farmers that the oil meal which they purchase is of poor quality, and that it fails to promote the growth of young stock or stimulate the flow of milk, as high class oil meal should do. In a few cases samples of the oil meal have been sent for chemical analysis. In all, twenty samples have been received, and of this number three

have been found to be adulterated, and a number of others have been found to be deficient in the most important nutrient, protein. The adulteration consists in mixing flax screenings with the fine ground oil meal. The mixture is ground so fine that the screenings are not easily detected. The composition, digestibility, and feeding value of pure oil meal are given in a former bulletin (No. 47) of this Station.

No. 2613. Oil meal sent by E. Cooley, Minneapolis, Minn. This sample caused stock to be very thirsty, and gave poor milk returns. When mixed with warm water there was a distinct odor of mustard.

No. 2747. Oil meal received from P. P. Eddy, Willmar, Minn. This meal gave poor results when fed to dairy calves. Purchased direct from linseed oil mill.

No. 3075. Oil meal brought to the laboratory by Mr. Scofield, Bloomington, Minn.

No. 2758. Oil cake direct from the press of an oil mill. The material was ground in the laboratory. Sample known to be pure.

TABLE LXVII.—Composition of Oil Meal Samples.

	No. 2613. Per Cent.	No. 2747. Per Cent.	No. 3075. Per Cent.	No. 2758. Per Cent.
Water.....	9.22	8.47		9.79
Ash.....	5.21	5.75	4.77	5.73
Fat.....	8.13	8.32	8.84	7.17
Protein.....	25.95	26.93	30.12	32.80
Fiber.....				5.40
Nitrogen Free Extract.....				36.11

Samples Nos. 2613 and 2747 are adulterated to the extent of at least 25 per cent. with flax screenings. The oil meal and screenings are ground very fine, but the foul weed seeds can be detected by a microscopic examination. The strong mustard odor in 2613 and its perceptible odor in 2747 is caused by the mustard seeds of the screenings. Sample No. 3075, when examined microscopically, showed the presence of wheat starch grains. This sample contains wheat shorts.

In purchasing oil meal, preference should be given to the coarser grades, rather than to those that are ground so fine as to conceal the screenings. Flax screenings can be more readily detected in the coarser grades. The odor of the sample when mixed with boiling water should be noted, and any distinct mustard odor may be taken as an indication of poor quality. A pound of crushed oil cake should absorb at least a quart of warm water, adding the water a little at a time and stirring well. The larger the amount of water absorbed, as a rule, the greater the per cent. of protein (or muscle-producing and milk-stimulating nutrient) and the more valuable the oil meal.

AMERICAN AND FOREIGN FLAXSEED.

Some European buyers believed that Russian flax was richer in oil than American, and preferred the foreign seed on that account. For purposes of analysis, the Minnesota State Railroad & Warehouse Commission collected samples from the European markets. The amount of oil in the various seeds is given in the following table:

TABLE LXVIII.—Oil in Flaxseed.

	Oil Per Cent.
Odessa, Russia.....	36.31
Bombay.....	39.08
Calcutta.....	37.88
Minnesota.....	37.61
American.....	37.50

There is practically no difference in the oil content of the American, Calcutta, and Minnesota samples; duplicate samples from the same car often show as great a variation as the results given here. The Russian flax contained the least oil.

WATER FOR RETTING FLAX.

The quality of linen produced from flax fiber is influenced to a great extent by the quality of the water used for retting the flax. The fiber retted in the river Lye, Belgium, is believed to be of such high commercial value because of the unique character of the river water. In order to secure the best results with the Cannon river, Minn., water, a chemical analysis was made, with the view of adding to the Cannon river water any materials that may be present in and characteristic of the Lye river water.

No. 1824, water from the Cannon river, Minn., used for retting flax.

No. 1825, water from the Lye river, Belgium, used for retting flax which produces the highest grade of linen.

It is to be observed that the Cannon river water differs from that of the river Lye in containing less of the alkaline chlorides and carbonates, a difference that can be largely corrected by adding these materials to the water in the retting tanks.

TABLE LXIX.—Composition of Water for Retting Flax.

	Cannon. River. Grams per litre.	Lye River. Grams per litre.
Total solids.....	.242	.3512
Calcium oxide.....	.0504	.0959
Magnesium oxide.....	.0044	.0092
Iron oxide, alumina and phosphric anhydrid.....	.0050	.0062
Sodium oxide.....	.0114	.0288
Potassium oxide.....	.0102	.0127
Chlorine.....	.0085	.0412
Carbon dioxide.....	.092	.0869
Silica.....	.0087	.0070
Organic matter and undetermined.....	.0614	.0628

ANIMAL FOODS.

The composition of bran, shorts, corn meal, and other mill products, when pure, has been so well established by the many analyses made at the different experiment stations that there is no apparent need of farther chemical analysis of individual samples

for the purpose of determining their feeding value, except when the materials are prepared in some unusual way. Wheat bran is less liable to be adulterated than wheat shorts, because any foreign matter can be readily detected in the coarse bran. In the case of shorts, however, there is a tendency to mix with the shorts the fine ground wheat screenings and weed seeds; the foreign material is not easily detected because the mixed shorts and screenings are ground so fine. A few new foods, mainly stock foods made by mixing various materials, have been analyzed, and in most cases the prices charged for the mixtures were found to be greatly in excess of the market value of the ingredients used.

No. 3000. Oat bran from oat meal mill, sent by John Matheson, president of the State Dairymen's Association.

No. 1822. Oat feed, from John Shields, Darwin, Minn.

No. 3076. International stock food, sent by F. W. Schrapel, Ottawa, Minn. "The package contains one cent's worth of material." The package weighed 26 1-2 grams,—nearly an ounce.

No. 2160. Wheat screenings, received from W. C. Currie, Euclid, Minn.

TABLE LXX.

	No. 3000. Oat Bran. Per Cent.	No. 1822. Oat Feed. Per Cent.	No. 2160. Wheat Screenings. Per Cent.	No. 3076. International Stock Food. Per Cent.
Water.....	5.95	12.29	12.47	5.43
Ash.....	6.45	2.93	2.13	13.11
Ether extract (fat).....	1.53	4.62	2.13	5.11
Protein.....	3.75	16.26	12.28	14.18
Nitrogen free extract.....	41.11	.....	63.53	.....
Fiber.....	41.21	.....	7.46	.....

The oat bran contains a very low per cent. of protein, about the same as present in straw. Oat feed, however, contains a high per cent. of protein, and is a more valuable food. Occasionally oat bran is sold as oat feed. There is, however, a great difference in the feeding value of the two. The wheat screenings contain a fair amount of protein, but are so variable in composition that what is true of one sample would not necessarily

be true of another. The International stock food has about the same amount of protein and fat as oats. The high per cent. of ash is due to salt and other minerals.

No. 1864. Cattle-feed mixture, from E. D. Childs, Crookston, Minn.

No. 3060. Speltz wheat, used for feeding animals, from Prof. Haecker, Dairy Division.

No. 1268. Corncobs, from corn raised on University farm.

No. 2854. Wild rice, from F. G. Bradbury, St. Paul. Occasionally used as human food.

No. 1264. Yellow corn, grown on University farm.

No. 1265. White corn, grown on University farm.

TABLE LXXI.

	No. 1864. Mixture Per Cent.	No. 3060. Speltz Wheat. Per Cent.	No. 1268. Corn Cobs. Per Cent.	No. 2854. Wild Rice. Per Cent.	No. 1264. Yellow Corn. Per Cent.	No. 1265. White Corn. Per Cent.
Water.....	12.89	10.02	10.75	9.29	12.08	11.91
Ash.....	4.34	3.25	1.20	1.42	1.51	1.47
Fat.....	5.72	2.25	1.44	.78	3.92	3.81
Protein.....	16.20	11.25	1.43	12.50	10.12	10.14
Fiber.....		9.22	32.15	4.89	2.21	2.28
Nitrogen free extract.....			54.08	71.17	70.18	71.49

The Speltz wheat has about the same protein content as ordinary oats. The hulls are the cause of the larger per cent. of fiber and ash than is found in ordinary wheat. The small amount of protein and digestible carbohydrates in corncobs suggests a low food value. Their main worth is probably due to the indigestible fiber diluting the feces, which from grains are apt to be small in amount and concentrated in composition. The wild rice sample contains as much protein as our ordinary grains. In some parts of the state wild rice grows abundantly in swamps and when it can be easily obtained it furnishes a cheap and valuable food. These statements do not apply to ordinary rice.

It is to be observed that, when grown under similar conditions, there is no material difference in protein or fat content between yellow and white corn. The main difference, chemical

ally, between yellow and white corn is in the coloring matter that is present in one and not in the other. There is no reason why any discrimination should be made against white corn on the ground that it contains less nutrients than yellow corn. The seed and conditions under which the corn has been produced, as soil, cultivation, and the use of manures, determine its character more than does its color.

RAPE.

The extensive use of rape as a forage crop for sheep has caused many inquiries to be made regarding its composition. The following analyses are calculated on the basis of the dry matter. When green the plant contains from 70 to 92 per cent. water, according to the stage of growth:

TABLE LXXII.—Composition of Rape.

	Water. Per Cent.	Composition of Dry Matter. Per Cent.		
		Ash.	Protein.	Fiber.
Rape, entire plant, nearly mature.....	84.51	7.60	11.75	15.29
Rape, leaves.....	88.16	7.50	17.04	11.06
Rape, half grown.....	92.48	9.24	12.44	.....
Rape, nearly mature.....	86.46	9.68	12.14	.....
Rape, first stages of growth.....	95.11	16.48	14.76	10.38
Rape, mature.....	76.44	8.01	9.21	12.03

The dry matter of the rape plant contains as much protein as clover hay. No figures are given for fat, because of the difficulty in separating this material. The ether extract is unusually high, ranging from 3 to 5 per cent., a large proportion of which is non-fatty material. The high protein content of rape makes it a valuable forage crop,—a fact that has been verified by practical experience.

MISCELLANEOUS FODDERS.

Under the head of "Miscellaneous Fodders" are given a few of the forage crops about which the most inquiry has been

made. In Bulletin No. 36 of this Station the composition and feeding value of our common grains and fodders are given. To this the reader is referred for the composition of foods not found in the following list:

Nos. 3072, 3073. Corn fodder, grown at the Grand Rapids Minn., sub-station.

No. 1931. Oat hay, as cut and cured for winter feeding.

No. 983. Pea hay, cut when small pods were beginning to form.

No. 2425. Dwarf German kale, cut when green, grown at the Division of Animal Husbandry.

No. 2433. Sand vetch, grown on University farm.

No. 2421. Cured sorghum, grown on University farm, cut and cured as hay.

No. 2422. Peas and oats. Cut green, and used as soiling crop.

Bromus Inermis samples (Austrian brome grass) Nos. 1917, 1918, 1919, 1920, 1932, grown on University farm in 1896. Nos. 2406 and 2406a, crop of 1896, were less mature than the 1897 samples.

TABLE LXXIII.—Composition of Green Fodders.

	Water. Per Cent.	Composition of Dry Matter. Per Cent.			
		Ash. Per Cent.	Ether Extract.	Protein. Per Cent.	Fiber. Per Cent.
No. 3072. Corn fodder.....	53.32	4.82	2.24	7.18	.....
No. 3073. Corn fodder.....	41.48	5.96	2.23	7.66	.....
No. 1931. Oat hay.....	20.37	8.01	3.45	9.55	31.28
No. 983. Pea hay.....	9.75	12.72	2.63	14.58	27.46
No. 2425. Dwarf German Kale.....	91.80	11.80	.....	22.68	15.20
No. 2433. Sand Vetch.....	7.50	10.60	3.81	18.56	29.30
No. 2421. Cured Sorghum	54.80	6.60	3.61	9.02	42.87
No. 2422. Peas and Oats..	72.41	9.12	2.94	12.84	29.16
No. 1916. <i>Bromus Inermis</i>	58.49	.....	.....	6.64	28.35
No. 1917. <i>Bromus Inermis</i>	49.35	6.98	.....	6.61	31.13
No. 1918. <i>Bromus Inermis</i>	58.81	6.03	.....	6.32	34.40
No. 1919. <i>Bromus Inermis</i>	49.25	5.22	.....	6.43	32.81
No. 1920. <i>Bromus Inermis</i>	33.06	6.56	.....	6.03	29.63
No. 1932. <i>Bromus Inermis</i>	44.58	7.84	.....	6.00	31.06
No. 2406. <i>Bromus Inermis</i>	68.30	9.50	.....	8.64	.....
No. 2406a. <i>Bromus Inermis</i>	64.40	9.26	.....	8.32	.....

The corn fodder samples Nos. 3072, 3073, grown in the northeastern part of the state, contain a normal amount of protein.

and other nutrients. These samples were analyzed to determine whether corn fodder grown so far north contained the full amount of nutrients. The analyses indicate that, so far as nutrients are concerned, these samples compare very favorably with corn fodder grown in other parts of the state. There has been some hesitancy on the part of farmers in the northern part of the state to grow corn fodder, because of the possibility of the corn not being fully matured before early frosts. For fodder purposes, the corn before it reaches maturity has passed that stage in its development when it contains its normal protein content. Although the protein may not be deposited in the form of mature kernels of corn, it is nevertheless present in the crop, and is in a valuable form for feeding purposes. There is no reason, as far as feeding value is concerned, why corn fodder should not be grown in all parts of the state.

The oat hay sample No. 1931 is characteristically rich in protein. Oats cut when fully headed out and cured as hay form a fodder that contains more protein than average timothy or prairie hay. In regions where clover is grown with difficulty, oat hay should be used as one of the main forage crops.

The high value of peas and oats as a forage crop is so well known that it is scarcely necessary to mention the fact. The analysis shows 12.84 per cent. of protein in the dry material, a much larger amount than is present in ordinary hay, and very nearly as much as in clover hay. From a chemical point of view, there are but few crops that have such a high forage value as peas and oats.

The *bromus inermis* samples analyzed in 1895 show a lower protein content than the 1896 samples. In 1896 the samples were taken at an earlier stage of growth, while those of 1895 were taken when the crop was nearly matured. If cut or fed before the crop becomes too mature, a valuable forage is secured. When over-ripe the protein content of *bromus inermis* is between that of oat straw and prairie hay. When properly cut and fed, it produces a valuable crop; but if allowed to mature it is less valuable for fodder purposes.

LIMESTONE FOR REFINING BEET SUGAR.

The limestone used for refining beet sugar must be of purity, as the presence of gypsum, magnesium compounds, alkaline matter causes trouble in the various refining operations. There is an abundance of limestone in the state, but all of the analyses made prior to 1897 showed that no stone had been found that could be used for sugar-house work. Prior to the opening of the St. Louis Park Beet Sugar Factory, in 1898, Hon. H. Keller collected samples of limestone from various parts of the state. These samples were analyzed and high grade limestone was found in three localities. Other samples have been received during the past year. Limestone suitable for making cement is frequently unsuitable for refining beet sugar, this is particularly true of our dolomite stone, from which a high grade of cement is made. The analyses are given of only the limestones that are suitable for beet-sugar work. Undoubtedly in other localities will be found that contain equally good stone. For the development of this industry, it is particularly fortunate that there is an abundance of high-grade limestone in the state, as at least a car-load of limestone per day is used by an ordinary beet sugar factory. In addition to the Faribault samples reported, a number of others have been analyzed, showing that there are a number of high-grade limestone quarries at this place.

TABLE LXXIV.—High Grade Limestones.

No.	Locality.	Silica.	Iron and Alumina.	Limc.	Carbon Dioxide.	Magnesia.	Sulphuric Anhydrid.	Soluble in Water.
2945	Faribault	6.53	.91	52.11	39.58	.39	.04	.24
2946	Faribault	4.15	1.06	52.78	41.75	.35	.01	.23
2947	Faribault	3.88	1.02	53.04	41.92	.06	.03	.17
2950	Fountain	2.49	1.58	52.50	41.30	.56	.....	.14
2953	Cannon Falls.....	7.30	2.78	48.99	40.05	.08	.....	.16
2959	Faribault	4.10	.96	53.17	41.20	.50	.01	.07
2992	Winthrop	.21	.61	55.67	42.80	.36	.10	.20
3460	Rockton	2.71	1.19	52.10	41.59	.28	.....	.....
3461	Shuster's Quarry	1.76	4.56	49.76	42.81	.40	.24	.....
3462	Shuster's Quarry	4.48	5.59	48.83	41.42	.45	.26	.....
3528	Faribault	2.60	.48	54.00	41.90	.04	.05	.20

SORGHUM SYRUPS.

TABLE LXXV.—Sorghum Syrups.

	No. 2739. Per Cent.	No. 2799. Per Cent.
Water.....	19.52	19.85
Beet Sugar.....	35.15	37.72
Reducing Sugar.....	28.27	25.24
Total Sugar.....	63.42	62.96
.....	2.00	3.74

No. 2739. Sent by J. W. Steed, Anoka, Minn.

No. 2799. Sent by Seth H. Kenney, Morristown, Minn.

Both samples compare very favorably in composition with published analyses of the best grades of sorghum produced in the southern latitudes.

SUGAR.

No. 3019. Sugar manufactured at the St. Louis Park Beet Sugar Factory. Sampled by a representative of the Experiment Station.

Sugar by polarization, 99.4 per cent. pure.

Inquiries are frequently received as to whether beet sugar is the same as cane sugar. Both are sucrose ($C_{12}H_{22}O_{11}$). When subjected to the same degree of refining, there is no difference between beet sugar and cane sugar. In fact, the difference cannot be detected by chemical analysis.

BUTTER.

The United States Department of Agriculture, in order to encourage a foreign market for butter, has, during the last two years, sent trial shipments of Minnesota creamery butter to the London market. Samples of some of this butter have been analyzed at the Minnesota Experiment Station, with the object of determining the composition and general character of the butter.

TABLE LXXVI.—Composition of Butter.

	Water.	Fat.	Salt and Ash.	Casein
No. 2748.....	10.83	86.84	1.68	.0
No. 2731.....	11.48	86.74	1.26	.1
No. 3044.....	12.86	84.68	1.56	.1
No. 3092.....	12.32	85.40	1.42	.1

The per cent. of salt and ash is less than that present in butter made for home use. The per cent. of casein and foreign matter is materially less than is found in many butters. It is apparent that by our improved processes of butter making less foreign matter is left in the product than by the old methods. The samples contain an average amount of water, and are quite uniform in composition.

DAIRY SALT.

Samples of dairy salt have been received and analyzed, including the Diamond Crystal, Worcester, Vacuum Pan, and other brands. The salts were all found to be of high purity, a difference in purity of less than one per cent. being observed. One of the main differences in the salt samples examined was in the fineness of the salt crystals. (The order of the numbers does not correspond with the brands given).

TABLE LXXVII.—Composition of Dairy Salt.

	Pure Sodium Chloride Per Cent.
No. 1134.....	99.9
No. 1208.....	98.5
No. 1080.....	98.5
No. 1081.....	98.5
No. 1082.....	99.9
No. 2022.....	99.9

TESTING SKIM MILK.

The testing of separator skim milk by the double-necked Ohlson bottle, suggested by Farrington, has led to many inquiries as to what the small divisions should be called, .05 or .10.

. Five samples of skim milk, analyzed by the chemical gravimetric method, gave the following results when tested with the Ohlson bottles, calling the divisions .05 per cent.:

TABLE LXXVIII.—Fat in Skim Milk.

	Per Cent. Fat.	
	Chemical Method.	Ohlson Test Bottles.
.....	.086	.05
.....	.072	.02
.....	.167	.08
.....	.082	.05
.....	.051	trace.

When the divisions are called .05 per cent. it is to be observed that the results are lower than those obtained by the chemical method. On the other hand, if the results are doubled they are nearly greater than the chemical results. Calling the divisions .10 per cent. brings the results nearer to those by the chemical method than when the scale is read .05 per cent. Farrington and others state that, "practically speaking, each division may be taken to show one-tenth of 1 per cent., if the column of fat obtained is only one or two divisions of the scale."

PRESERVATIVES.

The extensive sale of preservative powders and liquids for the preservation of milk, fruit, meats, and human food products in general, has led to many inquiries in regard to their influence on health. The preservative powders generally contain one or more of the following chemicals: borax, boric acid, salicylic acid, or formalin. Sanitary authorities, as a rule, seriously object to the use of any of these chemicals for the preservation of human foods, on the ground that they are all injurious to health. Since

their use can be avoided, it is safest and best not to employ for preserving milk fruits or other foods.

No. 3020. Liquid milk sweet, a preparation manufactured by the National Preservative Company, for the preservation of milk. This material was sent to the laboratory by Mr. George Haigh, secretary Mankato County Dairy Association. A chemical analysis of the material showed that it is a 40-per cent. solution of formalin, worth 35 cents per pound. Trials made in the laboratory showed that a normal lactic acid fermentation could not be induced in milk which contained formalin. It is questionable whether a butter of the best flavor can be produced when formalin is used for preserving the milk, because, by destroying the lactic acid ferment, it prevents normal ripening of the cream. Hence it will be seen that its use results in a financial loss to the creamery. Formalin is one of the most active germicides known and is extensively used in anatomical laboratories for the preservation of specimens.

No. 3122. Preservative compound, manufactured by Rockwell & Co., Jackson, Mich. Sent by Mrs. N. J. Solly, Elk Lake, Minn. The substance contains phosphoric soda, and free salicylic acid. The chief ingredients in the powder are salicylic acid and sodium phosphate. Prescott (Organic Analysis) that salicylic acid is "irritant to mucous surfaces." In many countries the use of salicylic acid for the preservation of foods is forbidden by law.

During the last session of the legislature a law was passed prohibiting the use of preservatives in milk and dairy products.

FERTILIZER MATERIALS.

An extended discussion of the different kinds of farm and commercial fertilizers is not attempted in this bulletin. Analyses are given of only those materials that have been sent for

amination by farmers and others. At the present time no commercial fertilizers are regularly offered for sale in the state. Except in special cases, as market gardening, it is doubtful if it would pay to use them, because the reserve fertility of the soil has not been drawn upon to such an extent that it demands replenishing. For ordinary crops, the use of farm manure, supplemented by waste and by-products, such as ashes, tankage, dried blood, and the manure from the large stock yards, the growing of clover and the judicious rotation of crops, will suffice to prevent decline in crop production.

No. 3124. Tankage from South St. Paul stock yards. Sent to the laboratory by T. P. Smith, St. Paul.

No. 3123. Dessicated sheep manure. Prepared at South St. Paul stock yards. Sent by T. P. Smith, St. Paul.

No. 1410. Tankage from Twin City Stock Yards. Analyzed for Horticultural Division.

No. 1411. Tankage from W. W. Rich Rendering Company. Analyzed for Horticultural Division.

No. 2757. Tankage mixture, Union Refining Company. Analyzed for Horticultural Division.

No. 2718. Sheep manure. Sent by Northrup, King & Co., Minneapolis.

No. 2751. Soft coal soot, from boiler flues of boilers of Minneapolis Water Works. Sent by Wyman Elliot, Minneapolis.

No. 2736. Nitrate of soda, sent by Farmers' Seed Company, Faribault, Minn.

Nos. 2020, 2021. Peat bog ashes, brought to the laboratory by C. C. Dikes, White Bear Lake, Minn. From a peat bog that had been burned over in 1896.

No. 1120. Ashes from sawmill. Soft wood and sawdust used for fuel; ashes unprotected from rain.

No. 1129. Hard wood ashes. From schoolhouse furnace, maple and oak used as fuel.

No. 1156. Dried Blood. From Twin City Stock Yards. Received from Horticultural Division.

TABLE LXXIX.—Composition of Fertilizer Materials.

	Nitrogen. Per Cent.	Phosphoric Acid. Per Cent.	Pota Per C
No. 3124. Tankage.....	7.05	11.13	.....
No. 3123. Dessicated Sheep Manure.	3.04	2.64	.....
No. 1410. Tankage.....	4.71	13.26	.....
No. 1411. Tankage.....	6.13	13.01	.....
No. 2757. Tankage Mixture.....	2.20	6.84	.....
No. 2718. Sheep Manure.....	.03	.....	.....
No. 2751. Soft Coal Soot.....	.....	.75	.....
No. 2786. Nitrate of Soda.....	14.75	.....	.....
No. 2020. Peat Bog Ashes.....	.....	1.90	2
No. 2022. Peat Bog Ashes.....	.....	2.15	2
No. 1120. Sawmill Ashes.....	.....	1.00	1
No. 1129. Hardwood Ashes.....	.....	3.00	7
No. 1156. Dried Blood.....	11.26	.....	.....

The tankage samples show extreme variation in composition. The same price per ton, however, was charged for all samples. Sample 'No. 1411, for example, has an agricultural value of \$3.36 per ton greater than No. 1410. The tankage mixture No. 2757 contains a large amount of land plaster. Tankage contains so little potash that this ingredient was not determined in the samples analyzed.

The dessicated sheep manure has been dried and treated so as to destroy weed seeds. It varies in composition according to the proportion of straw and litter originally present, and also according to the nature of the food which the animals receive. Sample manure No. 2718 was taken from a carload lot of fresh sheep manure. It was analyzed with the object of determining to what extent losses by heating and volatilization of ammonia had occurred during shipment. Five samples from different parts of the car showed a difference of less than .07 per cent. nitrogen. Compared with the fresh manure, there were only slight losses during the three weeks' shipment of the manure.

The soft coal soot, No. 2751, contains but little fertility. It has some mechanical value on sandy soils, enabling the land to hold more moisture; but the material supplies but little plant food. The nitrate of soda is about 92 per cent. pure. The peat bog ashes are not of any great value. It is doubtful if it is worth the pay to draw them any distance. They are so exceedingly bulky in weight, and low in potash and phosphoric acid that they are

very dilute manure. When the bogs are covered with timber, the ashes are more valuable. The sawmill ashes are of very poor quality, being soft wood leached ashes. The hard wood ashes from the schoolhouse furnace may be taken as a type of high-grade ashes. The best grades of ashes should be more extensively used for gardening purposes than they are at present.

MISCELLANEOUS SUBSTANCES.

No. 2077. Murnane's Germicide for hog cholera, brought to the laboratory for analysis by T. A. Haigh, Mankato, Minn. Manufactured at 317 Washburn block, St. Paul. A nostrum sold for curing hog cholera. Extract from circular: "Take a piece of flannel 1x2 inches in size, and apply a portion of Germicide about twice the size of a pea. Fold the flannel once with the preparation on the inside, rubbing it slightly so that it will adhere to the flannel. Fasten this to the ear of the hog with an ordinary string ring." Why it is placed on the ear in preference to some other part of the body is not stated. The Division of Animal Industry of the United States Department of Agriculture states that no medicine has yet been found that will cure or prevent this disease. The material contains:

Carbolic acid, Copper, Alumina, Magnesia, Glycerine, Zinc, Soda, Sand, Tar, Lead, Potash, Sulphuric anhydride, Vaseline, Boron, Lime.

About five cents' worth of the above mixture is put in a small jar and sold for \$5.

No. 2078. Siebner's Potato Bug Exterminator Compound. Manufactured at Waukesha, Wis., P. O. Box 1024. Brought to the laboratory by Dr. Lugger. A nostrum proposed to render potatoes "bug-proof." The seed potatoes are treated in a box or barrel with layers of this material, and left 15 hours. The chemical and microscopic analyses showed that the material was made of wood ashes, land plaster, clay, and a small amount of corrosive sublimate, a very poisonous material. No

explanation was offered as to how this treatment of the potatoes was expected to kill the bugs on the potato vines.

No. 1133. A germicide, insecticide, and fertilizer. Brought to the laboratory for analysis by Dr. Lugger. Put up in Chicago. Place of manufacture, and name of manufacturer not given. The solution contained arsenic and caustic potash. When used according to directions, Dr. Lugger reports that it destroyed all the leaves on a plum tree.

No. 2095. The American Soil Renewer and Insecticide. A preparation for fertilizing crops, killing insects, etc. Brought for analysis to the laboratory by Dr. Lugger.

Common salt	79.61 per cent
Land plaster	4.50 per cent
Organic matter	11.67 per cent
Water	4.22 per cent

The organic matter gave alkaloid reactions, resembling veratrine, the alkaloid found in white hellebore.

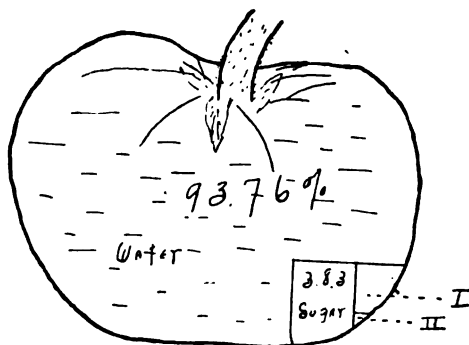
No. 2180. Russian Thistle Exterminator. A preparation sold for destroying the Russian thistle by spraying. The substance contained arsenic and soda. There was no label on the package, or any indication that it was a poisonous substance. This is a dangerous material to use, because poisoned thistles are liable to be blown into wells, watering troughs, or into haystacks and so cause the death of animals feeding upon the hay or using the water.

TOMATOES.

COMPOSITION AND FOOD VALUE.

HARRY SNYDER.

The extensive use of tomatoes as an article of food has caused many inquiries to be made as to their food value. The nutrient present in tomatoes in the largest amount is sugar, while the organic acids are the main substances which give individuality or character. In tables of analysis tomatoes are given as con-



— Composition of Tomato —

I Other Solids.

II Protein

taining from 92 to 95 per cent. water, .45 per cent. ash, .90 to 1.00 protein, and 3.80 to 4.80 per cent. of carbohydrates. The per

cent. of sugar, which constitutes the main part of the carbohydrates, is given by various analysts as ranging from .6 to 4.50 per cent. This wide range of sugar is greater than can reasonably be expected in a material containing so little dry matter as the tomato. When calculated on the water-free basis, it would be equivalent to a range of from 10 to 80 per cent., or more of the total dry matter. On the water-free basis is 10 per cent. of the tomato sugar, or is there a larger amount? In view of the lack of uniformity of results as to the composition of the tomato, complete analyses were made of three typical samples: (1) Acme; (2) Livingston; (3) Dwarf Aristocrat.

Sugar.—For this determination 100 grams (nearly 4 oz.) of the fresh sample was reduced to a pulp, and the sugar determined by the official gravimetric process. The results were as follows:

	Sample No. 1. Per Cent.	Sample No. 1. Per Cent.	Sample No. 1. Per Cent.
Levulose and dextrose.....	2.25	2.44	2.06
Sucrose (cane sugar).....	1.60	1.62	1.73
Total	3.85	4.06	3.79

A compound sample, made of equal parts of Nos. 1, 2 and 3, was prepared, and submitted to further examination. The polarizations before and after inversion, combined with the usual gravimetric observations, showed that the reducing sugars were composed approximately of equal parts of levulose and dextrose, making the sugar content of the sample as follows:

	Per Cent.
Levulose	1.
Dextrose	1.
Sucrose	1.
Total	3.

The same amount of sugar could not be obtained from the dry residue of the tomato as from the fresh material. When sample No. 1 was dried in a water oven, and the sugar in the dry residue extracted and determined, only 2.04 per cent. was

obtained, while the fresh tomato yielded 3.85 per cent. The tomato yields when dried in the water oven a black charred mass which resembles charcoal. Before the water is entirely removed the substance appears to undergo a material change. The combined action of the heat, organic acids, and ferments, undoubtedly has some influence upon the sugar of the tomato, particularly upon the levulose which is exceedingly easily decomposed by heat and acids (O'Sullivan). In order to determine the extent to which the heat and acids influence the sugar content of the tomato, a solution containing by analysis 1.79 grams of levulose and .85 grams of malic acid was evaporated to dryness upon asbestos paper and left in the drying oven the same length of time as the tomato samples. A black, charred mass was obtained, of less intensity of color than that from the tomato. Only .41 grams of reducing sugar could be recovered from the 1.79 grams originally taken, equivalent to a loss of 77.7 per cent. of the levulose or fruit sugar. The destruction of the levulose by the prolonged drying in the presence of the malic acid explains the discrepancy in the sugar per centage of the tomato as obtained by different analysts, because some have obtained their sugar results from the dried residue, while others have used the fresh material. This chemical change is not necessarily confined to the levulose of the fresh sample. When the tomato is dried the sucrose undergoes inversion, and the levulose thus formed undergoes the same change as the pre-existing levulose. That this is true is indicated from the results and by direct experiments. In the compound sample reported the theoretical amount of levulose formed from the sucrose is .82 per cent., which, added to the levulose already present, gives a total of 1.94 per cent., leaving 1.95 per cent. of dextrose. The .04 per cent. of total sugar secured from the dried residue was, therefore, mainly dextrose. This same change was observed when solutions composed of sucrose, levulose, and malic acid were evaporated and heated in a water oven.

The fact that the mixed sugars of the tomato suffer such material change in drying indicates that the sugar in the dried residue of fruits and vegetables may not always be taken as repre-

sending the sugar content of the fresh substance. Drying in vacuum would probably be the only way of avoiding the changes.

Protein.—The tomato contains relatively a low per cent. protein. The samples examined yielded about .5 per cent. The tomato is ordinarily considered as containing from .9 to 1.00 per cent. protein. Fifty-five per cent. of the total nitrogen of tomato is, however, in non-proteid forms. The samples analyzed gave the following results:

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.
Total nitrogen	.17	.18	
Proteid nitrogen	.08	.08	
Non-proteid nitrogen	.09	.10	

Fat.—The direct extraction of the dry matter of the tomato gives about .5 per cent. of ether extract, commonly called fat. If the residue is first extracted with alcohol, a much smaller amount of ether extract is obtained, as will be observed from the following results:

1. Direct extraction of residue
2. After extraction with alcohol
3. Ether extract 1, soluble in alcohol

From these results it is evident that about 90 per cent. of the ether extract of the tomato consists of non-fatty material.

TABLE LXXX.—Composition of Tomatoes.

	Sample 1. Per Cent.	Sample 2. Per Cent.	Sample 3. Per Cent.
Sucrose (cane sugar).....	1.60	1.62	1.78
Dextrose (glucose).....	1.12	1.12	1.08
Levulose (fruit sugar).....	1.13	1.12	1.03
Protein.....	.50	.50	.44
Amides.....	.36	.40	.36
Fat.....	.05		
Malic Acid.....	.37	.47	.41
Ash.....	.69	.56	.54
Insoluble in Acid.....	.32	.34	.37
Undetermined.....	.25	.11	.16
Water.....	93.61	93.76	93.93
Total.....	100.	100.	100.
Total Solids.....	6.39	6.24	6.07

LOSSES OF NUTRIENTS IN CANNING TOMATOES.

When the tomato is to be used for food, care should be taken to retain all of the juice, as the nutrients are present largely in soluble form, and any diminution of the amount of juice entails a corresponding loss of nutrients.

In the canning of tomatoes it is sometimes customary to allow the juice to drain from the solids, with the object of securing a more concentrated product. In order to determine the losses by this method of preservation, two cans were prepared, one with and one without the juice. The amounts of material taken, and the weights of the products secured are given in the following table:

TABLE LXXXI.—Canned Tomatoes.

	Can 1. Grams. With Juice.	Can 2. Grams. Without Juice.
Tomatoes used, 3 lbs.....	1362	1362
Juice excluded.....	302	643
Weight of canned product.....	708	564
Loss of Water, etc., by evaporation.....	352	155

When 301 grams (11 ozs) of juice, from 3 pounds of tomatoes, were excluded from can 2, the losses as determined by analysis, compared with can 1, were 11.74 grams of sugar. The total amount in the three pounds of tomatoes was 53.11 grams. An unnecessary loss of 22 per cent. of the total sugar of the tomato resulted from the exclusion of the juices.

When the juice was retained, and the product concentrated by evaporation, as in can No. 1, the material finally yielded 9.62 per cent. solids and 5.5 per cent. sugar. As prepared for the table, a pound of canned tomatoes like No. 1 would contain about 14.4 grams of sugar (6/7 oz), and about 18.4 grams of all other nutrients combined (a little over 1/2 oz.). Calculated on the basis of nutrients, this is not a large amount, but the tomato has an additional value, difficult to determine,—its favorable influence upon the digestibility of other foods.



THE PROTEIDS OF WHEAT FLOUR.

HARRY SNYDER.

The proteids of wheat have been studied by a number of investigators. One of the earliest and most complete investigations of the subject was made by Ritthausen,¹ who identified four proteids, namely, (1) gluten-casein, (2) gliadin (plant gluten), (3) mucedin, and (4) gluten-fibrin. Gluten-casein is insoluble in hot and cold alcohol, but soluble in dilute alkali solutions from which it may be again precipitated by acids. Gliadin also is soluble in dilute alkali solutions, and may be re-precipitated by acids. It is soluble, too, in warm dilute alcohol, from which it is again precipitated on cooling. Mucedin is similar to gliadin, though less soluble in strong alcohol. It is readily soluble at ordinary temperatures in 60 to 70 per cent alcohol, and also in acetic acid. Gluten-fibrin is soluble in dilute boiling alcohol; it is again precipitated on cooling.

Among the more recent contributions to this subject is the work of Osborne and Voorhees.² According to their investigations, there are five separate proteids in wheat; namely, (1) gliadin, (2) glutenin, (3) edestin (a globulin), (4) leucosin (an albumin), and (5) a proteose.

From the results reported in this bulletin it will be observed that about 89 per cent of the total proteids of flour is in the form of gluten. In the testing of flour, gluten is obtained by washing a sample of dough with cold water to remove the starch and other

¹Die Eiweisskörper der getreidearten, Hulsenfruchte und Oelsamen. Bonn, 1872.
(Contains references to his earlier publications.)

²Amer. Chem. Jour., 15 (1893), p. 392.

compounds. The gluten mass is usually very elastic and tenacious, varying in quality according to the nature of the flour from which it is obtained. Inasmuch as both the food value and the baking quality of flour are determined mainly by the character of the proteids, it is unnecessary to speak of the importance of a study of these bodies in relation to the milling of wheat, practical bread making, and human food investigations.

In a former report, Minn. Bulletin 54, it was shown that wheat gluten is composed of two proteids, gliadin and glutenin; these two bodies form about 85 per cent of the proteids of wheat. The gliadin may be extracted from either gluten or flour with a 70 per cent solution of alcohol. The gliadin obtained after evaporating the alcohol is in the form of thin, transparent flakes which resemble gelatine. In fact, gliadin was called by the earlier investigators plant gelatine. When moistened the gliadin expands and forms a mucilagenous mass. When more water is added, a small amount is dissolved. Gliadin is soluble in dilute acid and alkali solutions, and in many samples of flour, particularly those which have been kept for some time, there is sufficient acid developed to combine with and render soluble appreciable amounts of this proteid. Gliadin, like all of the wheat proteids, is characterized by a high per cent of nitrogen. It takes a very important part in bread making, and is the material which binds together the flour to form dough and enables the mass to expand by retaining the gas generated by the yeast. The gluten from ordinary flour contains from 60 to 70 per cent of gliadin, the remaining 30 to 40 per cent being glutenin.

Glutenin is the proteid which remains after extracting the gliadin from the gluten. When dry and pure it forms a light gray mass, which may be reduced to a fine powder. It is insoluble in dilute alcohol and salt solutions, and is only sparingly soluble in water. It is readily soluble in dilute acid and alkali solutions. This proteid also takes an important part in bread making. It combines mechanically with the gliadin, and "serve

*Note. The summary of the work by Ritthansen, Guthrie, Fleurent and O'Brien was contributed by Dr. Langworthy, of the office of Experiment Stations N. S. Department of Agriculture, Washington, D. C.

as a nucleus to which the gliadin adheres" and prevents the dough from becoming too soft and sticky. When these two proteids are present in flour in the proportion of 65 per cent of gliadin to 35 per cent of glutenin, a much better quality of bread can be produced, than from flour containing the same amount of total proteids, 75 per cent of which is gliadin and 25 per cent glutenin.

In addition to gliadin and glutenin, which are the two main proteids of wheat, there are small amounts of other proteid bodies present in wheat, which, according to Osborne and Voorhees, have the following characteristics: Leucosin, an albumin, is soluble in water and coagulated at 52° C. (Ordinary flour contains from 0.25 to 0.40 per cent albumin.) Edestin, a globulin, is soluble in dilute salt solutions, and coagulated at temperatures above 100° C. (Flour ordinarily contains from 0.75 to 1.50 per cent of globulin.) After removing the albumin and globulin from the water and salt solutions used in separating the above proteids, there remains a soluble proteid, a proteose which is coagulated by tannic acid and other reagents.

The gliadin-glutenin ratio is an important matter to consider in determining the bread-making qualities of flours. Girard¹ states that the gliadin-glutenin ratio in winter wheat is about 75:25. From Osborne and Voorhees' investigations it would appear that wheat gluten is composed of nearly equal parts of gliadin and glutenin.² This matter was recently studied by Guthrie.³ A number of experiments were made on (1) the strength, i. e. the amount of water which flour made from various sorts of Australian-grown wheat would absorb; (2) the gluten content; (3) the proportion of glutenin to gliadin in the gluten; and (4) the physical nature of the gluten of the various flours. The author concludes that the strength or water-absorbing capacity of flour depends directly upon the relative proportion of the glutenin and gliadin of the gluten. When these two bodies are present in about the same proportion, the flour is stronger than that which contains a larger proportion of glutenin. Flours in which glutenin predominates

¹Compt. Rend. Acad. Sci. Paris, 123, p. 327.

²Am. Chem. Jour., p. 392

³Ag. Gaz. N. S. Wales, 7, 1896.

yield strong, tough, elastic, non-adhesive glutens. When gliadin predominates the gluten is weak, sticky, and inelastic. In a later publication¹ Guthrie, with E. H. Gurney, reports the determination of gluten and the strength of a number of samples of flour.

According to Fleurent the respective proportions of gliadin and glutenin in gluten are about as follows: Glutenin, from 18 to 25 per cent of the total gluten; gliadin, from 60 to 80 per cent of the total gluten. The gliadin is regarded as the true agglutinating matter, and not the glutenin, and the reason the proteids of the other cereals do not form a sticky dough is because the quantity of gliadin is comparatively small, ranging from 8.17 per cent of the total amount of proteids in barley to 47.50 per cent in maize.

The distribution of gluten and its constituents in the starch layer of wheat has also been recently investigated by Fleurent. The results were published after the investigations described in this bulletin were completed. Fleurent determined the gluten and gliadin in the gluten in several sorts of wheat. In his opinion the results show that the gluten content and the composition of the gluten vary in different varieties of wheat and also in the products obtained from the same wheat at different stages of grinding. The quantity of gluten increases from the center of the wheat grain toward the periphery of the starch layer, while the gluten contains a higher percentage of glutenin as it approaches the interior of the grain.

An extended study of the proteids of wheat flour and wheat germ has been reported by O'Brien.³ According to this author the flour contains the following proteids:

1. Globulins: precipitated by carbon dioxide and by dialysis from neutral saline solutions.

(a) myosin-type: coagulating at about 55°; soluble in dilute sodium chloride and magnesium sulphate solutions, precipitated by excess.

¹Ag. Gaz. N. S. Wales, 8, 1897.

²Compt. Rend. Acad. Sci. Paris, 126, p. 1592.

³Ann. Bot. 9 (1895) pp. 171 and 543.

(b) *vitellin-type*, coagulating at 75-80°; soluble in dilute sodium chloride solution, not precipitated by excess; soluble in dilute magnesium sulphate solution, precipitated by excess.

2. Proteose: not coagulated by heat.

3. Mother-substance of gluten; only attainable in hydrated form as either gliadin by extracting flour with 75-90 per cent alcohol; or gluten, by treating flour with water.

The correspondence between the globulins of the germ and those of flour are regarded as fairly complete. O'Brien regards the vitellin and myosin which make up what he calls globulin as identical with the globulin (edestin) and albumin (leucosin) of Osborne and Voorhees. The proteoses are also regarded as identical. The author does not agree with Osborne and Voorhees' conclusions that gluten is made up of gliadin and glutenin; that these constituents exist in flour in the same proportion as in gluten, and therefore that gluten may be said to exist as such in the flour. In his opinion these substances may be extracted from gluten in varying proportions according to the method employed. This suggests that the one may be derived from the other; and this is probably the less soluble substance (zymom) that is derived from the more soluble (gliadin); hence the alcohol-soluble substance (gliadin) is ultimately co-extensive with gluten."

O'Brien believes his investigations indicate "the existence of one mother-substance in flour which readily undergoes hydration, giving rise to gluten. For we can, as it were, intercept hydration at any point and obtain consequently a larger or a smaller amount of alcohol-soluble substance by extracting gluten with alcohol at an earlier or later stage in its progress to almost complete insolubility. Moreover, it seems almost impossible completely to extract from flour the whole of the alcohol-soluble product with 75 per cent alcohol in the cold; this again is suggestive of a gradual hydration of the mother-substance."

O'Brien's article includes an extended review of the literature of the subject, covering a period from the discovery of gluten by Beccari in 1766 to the present time.

Inasmuch as the bread-making qualities of different flours are so variable it was considered advisable to make a study of the proteids of a number of samples of flour and mill products. In general, the methods proposed by Osborn and Voorhees for the separation of these proteids were followed.

METHODS EMPLOYED IN SEPARATION OF PROTEIDS.

Water-soluble nitrogen.—Fifteen grams of flour were weighed into a flask and 250 cc. distilled water added, the temperature being kept at about 30° by placing the flask in water of the same temperature. The flask was shaken occasionally. After two hours, 200 cc. of the clear filtrate were placed in a Kjeldahl digestion flask containing a little sulphuric acid and evaporated nearly to dryness, when the remainder of the acid necessary for oxidation was added and the determination of nitrogen completed in the usual way. When it was also desired to separate water-soluble gliadin 30 grams of flour and 500 cc. of water were used. One-half of the filtrate was evaporated nearly to dryness and the residue treated with 70 per cent alcohol to extract the soluble gliadin. The extract was filtered through a small filter. The filter paper with the insoluble proteid residue was placed in a Kjeldahl flask and the nitrogen in it determined in the usual way.

Salt-soluble nitrogen.—After removing the water-soluble proteids, the flour residue was placed in a flask and 500 cc. of 10 per cent sodium chlorid solution added. After standing for about two hours at 30°, the nitrogen in the extract was determined in the case of proteid soluble in water.

Gliadin.—Five grams of flour or other material were weighed into a flask and 250 cc. of 70 per cent alcohol added, the contents of the flask being shaken at intervals of half an hour for three hours. The alcohol was left in contact with the flour for about eighteen hours. The alcoholic extract was then filtered and 100 cc. of the filtrate placed in a Kjeldahl digestion flask connected

with a condenser. The alcohol was removed by distilling and the nitrogen in the residue determined in the usual way. With good or unsound flours a correction must be made for soluble amides.

Glutenin.—The residue from the gliadin determination was washed with 70 per cent alcohol until the washings no longer gave a reaction for proteids. It was then transferred to a flask and 100 cc. of a 5 per cent solution of sodium chlorid added to remove globulin and other proteids. After two hours' extraction the residue was washed with distilled water and transferred to a flask, 250 cc. of a 0.2 per cent solution of potassium hydroxide added, and after three hours' extraction the solution filtered, and the nitrogen in 200 cc. of the filtrate determined in the usual way. The glutenin determination is the most troublesome of all because the other proteids must be removed before it can be extracted with potassium hydroxide. For all practical purposes the glutenin may be estimated by difference. Results thus obtained are within 0.1 per cent of the actual amount recovered with potassium hydroxide.

Amid nitrogen.—Fifteen grams of flour were treated as described for the determination of water-soluble proteids. Fifteen cubic centimeters of Stutzer's copper solution were added to 200 cc. of the filtrate and the albuminoid nitrogen determination was made in the usual way. The difference between the nitrogen of the water-soluble proteid and the albuminoid nitrogen represents the amid nitrogen.

Tannic acid was also used to precipitate the total soluble proteid matter, and gave satisfactory results. The usual method for the determination of albuminoid nitrogen is not applicable to flour because a paste-like mass is formed which can not be readily filtered.

The complete separation of the several proteids in flour can only be approximately secured, because the solubilities of the separate proteids will not permit of the extraction of one proteid without being more or less contaminated with other proteids. For general comparative purposes, however, the separation of the proteids into water-soluble, salt-soluble, alcohol-soluble, and in-

soluble proteids gives valuable results. The presence of variable amounts of organic acids in wheat and flour causes the formation of acid proteids, so that the analyst is dealing with proteid derivations rather than "native" proteins.

DESCRIPTION OF SAMPLES USED.

No. 1. First grade Patent flour, highest grade made from spring wheat. The flour was milled by the Consolidated Milling Co., of Minneapolis, March 16, 1897. The roller process was used. About 75 per cent of the wheat is recovered as flour.

No. 2. Second Grade Patent flour, just a shade darker color than No. 1. This sample was also milled by the Consolidated Milling Co., and was from the same lot of wheat as No. 1.

No. 3. Third grade or straight flour: From the same wheat as No. 1. The gluten from the flour was slightly different physical properties from No. 1, which possessed greater power of expansion, producing the lightest as well as the white grade of bread.

No. 4. Patent flour, highest grade, made from spring wheat. The flour was milled by the Washburn-Crosby Co., of Minneapolis, Minnesota, March 18, 1897. The roller process was employed and about seventy-five per cent of the wheat was recovered as flour.

No. 5. Patent flour made from winter wheat grown in Washington. A type of flour from soft winter wheat.

No. 6. First bakers' grade of flour, a product of the same wheat as flour No. 4. The bakers' grades of flour are not as light in color as the patent grades, and the gluten does not possess great a power of expansion. The greatest difference between the patent and bakers' grades of flour is in the physical properties of the gluten, as power of expansion, capacity to absorb water, color, elasticity, etc.

No. 7. First bakers' grade of flour, a product of the same wheat as flour sample No. 1.

No. 8. Second bakers' grade of flour, another grade of flour from the same wheat as flour No. I.

No. 9. Red dog flour: From the same wheat as No. I. This is the lowest grade of flour that is manufactured. It is frequently used for feeding animals. The gluten in this flour has very poor physical qualities compared with No. I.

No. 10. Red dog flour, produced in the milling of flour No. 4.

No. 11. Wheat germ obtained in the milling of flour No. 4.

The germ, although very rich in protein, is excluded from the flour on account of the poor physical and baking qualities of its proteids. It is used for making "Breakfast Foods," compressed yeast, and for feeding purposes. From four to seven per cent of the wheat is obtained as wheat germ.

No. 12. Wheat germ obtained in milling sample No. I.

No. 13. Wheat shorts, a product obtained in milling sample No. I.

No. 14. Wheat shorts, obtained in the milling of sample No. 4.

No. 15. Wheat bran, a product obtained in the milling of sample No. I.

No. 16. Wheat bran from the milling of flour No. 4.

TABLE LXXXII. Nitrogen in the Proteids of Flour and Milled Products.

No. of Sample.		NITROGEN OF					Total Nitrogen.
		Water-Soluble Proteid.	Salt-Soluble Proteid.	Alcohol-Soluble Proteid.	Potash-Soluble Proteid.		
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
1	First grade patent flour.....	.465	.218	.791	1.000	2.297	
2	Second grade patent flour.....	.369	.181	.317	.931	2.177	
3	Third grade patent flour.....	.282	.149	1.108	.878	2.111	
4	First grade patent flour from spring wheat	.391	.348	.869	1.287	2.410	
5	Patent flour from winter wheat.....	.277	.194	1.075	.472	1.455	
6	First grade baker's flour.....	.258	.235	1.046	1.091	2.837	
7	Baker's grade flour.....	.388	.422	.770	1.340	2.559	
8	Baker's grade flour.....	.381	.311	1.524	.927	3.284	
9	Red dog flour.....	1.112	.496	.802	1.283	3.530	
10	Red dog flour.....	1.027	.647	.914	1.128	3.669	
11	Wheat germ.....	1.460	.876	1.106	1.134	4.296	
12	Wheat germ.....	1.804	.915	1.084	1.248	5.706	
13	Wheat shorts.....	1.100	.515	.832	.886	3.130	
14	Wheat shorts.....	.732	.818	.739	.762	2.818	
15	Wheat bran.....	.787	.884	.802	.622	2.871	
16	Wheat bran.....	.559	.958	.801	.428	2.620	

DISCUSSION OF RESULTS.

The water-soluble nitrogen reported in the above table represents the amid, albumin, and proteose nitrogen, with variable amounts of gliadin nitrogen. The amid nitrogen was determined in six samples with the following results:

TABLE LXXXIII. Amid Nitrogen in Flour, Shorts and Wheat Germ

	Per Cent.
No. 1, Patent flour.....	.019
No. 2, Patent flour.....	.012
No. 7, Bakers' flour.....	.021
No. 8, Bakers' flour.....	.024
No. 12, Shorts.....	.074
No. 13, Germ.....	.12

The nitrogen of water soluble gliadin in a number of samples of patent flour was also determined by evaporating an aliquot portion of the solution nearly to dryness and extracting the residue with 70 per cent alcohol. The following table shows the total nitrogen and the nitrogen of water-soluble gliadin in the sample, as well as the nitrogen of albumin and proteose, this being obtained by subtracting the nitrogen of water-soluble gliadin from the total.

TABLE LXXXIV. Nitrogen of Water Soluble Gliadin, and Albumin and Proteose in Flour.

Sample.	Total Nitrogen.	Nitrogen of Soluble Gliadin.	Nitrogen of Albumin and Proteose.
	Per Cent.	Per Cent.	Per Cent.
Patent flour No. 1.....	.465	.389	.076
Patent flour No. 2.....	.369	.284	.075
Patent flour No. 3.....	.282	.203	.079
Patent flour No. 4.....	.391	.308	.083
Bakers' flour No. 6.....	.258	.122	.136
Bakers' flour No. 8.....	.381	.287	.094

The aqueous extract from the flours contained from 0.2 to 0.389 per cent of proteid nitrogen, soluble in dilute alcohol. Making corrections for the soluble gliadin and for the amid nitrogen, the albumin-proteose nitrogen was found to range from 0.075 to 0.083. A flour containing a high per cent of soluble proteids as albumin and proteose bodies possesses poor keeping qualities. Such a flour usually contains a high percentage

germ proteids which are associated with the soluble ferments that cause the flour to become unsound.

The nitrogen of the salt-soluble proteids in the flours ranged from 0.14 per cent in the patent to 0.42 per cent in the low grade bakers' flour. In the four patent flours the average globulin content was 0.95 per cent. The proteids in the form of albumin, globulin, and proteose amounted in all to 1.45 per cent, equivalent to nearly 11 per cent of the total proteids of the flour. The humid nitrogen in the flour was slightly less than 1 per cent, consequently the gluten proteids constituted about 88 per cent of the total nitrogen in the flour.

In the offal products examined, bran, germ, and shorts, the relative percentage of the water-soluble as well as salt-soluble, proteids was much higher than in the samples of flour. In the bran the gliadin and glutenin make up less than half of the total. The germ contained the highest percentage of water-soluble proteids. From the results it appears that more non-gluten proteids (albumin, globulin, and proteose), are present in the offal products than in the flour products.

The process of milling results partly in a mechanical separation of the various proteids, the non-gluten proteids being recovered mainly in the by-products, while the gluten proteids are recovered mainly in the flour. In the wheat from 80 to 85 per cent of the total nitrogen is in the form of gluten, while in the flour there is from 86 to 89 per cent in this form.

In the table it will be observed that in some cases the sum of the water, salt, alcohol, and potash-soluble nitrogen in flour exceeds the total nitrogen by 0.1 to 0.3 per cent. This is due to the fact that all the determinations were not made from the same weighed quantity of flour and that some of the proteids are classed in more than one group. The nitrogen of water-soluble proteids, as previously stated, contains from 0.12 to 0.38 per cent soluble gliadin nitrogen. Many of the gliadin determinations for the flour were made from separate portions of flour or by extracting the gluten mass with alcohol. This resulted in part of the gliadin being recovered in two places. When, however, corrections are

made for the soluble gliadin, the sum is always less than the total nitrogen.

Osborne and Vorhees¹ determinations of the different proteids of finely ground wheat are as follows:

TABLE LXXXV. Proteids of Wheat.

	Spring Wheat.		Winter Wheat.	
	Nitrogen.	Protein.	Nitrogen.	Protein.
Glutenin.....	.8245	4.683	.7346	4.173
Gliadin.....	.6977	3.96	.6884	3.910
Globulin.....	.1148	.624	.1148	.625
Albumin.....	.0657	.391	.0603	.359
Coagulum.....	.0453	.269	.0879	.228
Proteose.....	.0341	.213	.0791	.432
From H ₂ O washings of gluten.....	.2239	1.272	.1552	.881
Total.....	2.005	11.415	1.87	10.60
Flour.....	2.10	11.93	1.94	10.96

Osborne and Voorhees state that "the washings of the gluten were collected in jars and allowed to settle; the sediment was washed with water and with very strong alcohol, and dried and weighed. The nitrogen in each case was then determined."

It is to be observed that in the case of the spring wheat 11 per cent, and of the winter wheat nearly 9 per cent of the total nitrogen was found in the washings from the gluten. The method as described above would indicate that this nitrogen is present as insoluble nitrogen, presumably as particles of gluten lost in the washings.

They also state that "Direct treatment of the material with alcohol yields extracts containing gliadin in exactly the same proportion as is obtained from the gluten made from an equal quantity of flour, and extracting either flour or gluten with alcohol after complete exhaustion with sodium chlorid gives the same proportion of gliadin."

In Osborne and Voorhees' determinations the sum of the albumin, coagulum and proteose nitrogen for the spring wheat amounts to 0.14 per cent, and for the winter wheat to 0.176 per cent. In the determinations reported in this investigation the

¹Am. Chem. Jour., 16 (1893), p. 461.

total amount of albumin, coagulum and proteose nitrogen is given ranging from 0.072 to 0.129 per cent. It is also found that the water-soluble matter contained from 0.12 to 0.39 per cent of gliadin nitrogen.

In the investigations reported in this bulletin it was found that the direct extraction of the flour with alcohol for the determination of the gliadin gave better results and offered fewer difficulties than the extraction of the gluten mass. Some glutens form a rubber-like mass which is nearly impervious to the action of alcohol.

The figures given in table LXXXII for the nitrogen of alcohol-soluble proteids can not be taken as representing the total gliadin-nitrogen of the flours except in those cases where the flour was directly extracted with alcohol since (1) the gluten mass often resists the action of the alcohol; (2) mechanical losses occur in obtaining the gluten; and (3) if the flour is first extracted with distilled water from 0.1 to 0.3 per cent of gliadin nitrogen is dissolved.

Because of the important part which gliadin takes in bread-making, a separate series of gliadin nitrogen determinations was made with six samples of flour in the following way: Five grams of flour were weighed into a flask, 250 cc. of 70 per cent alcohol added, and the flask shaken at half hour intervals for three hours. The alcohol was left in contact with the flour for fifteen hours; 50 cc. of the filtered solution was then measured into a Kjeldahl digestion flask which was connected with a condenser, and the alcohol distilled. The nitrogen was then determined in the usual way. The results were as follows:

TABLE LXXXVI. Gliadin Nitrogen in Wheat Flour.

	Gliadin Nitrogen.	Total Nitrogen.	Gliadin Nitrogen in Total Nitrogen.
	Per Cent.	Per Cent.	Per Cent.
Patent flour.....	1.23	1.95	63.09
Patent flour.....	1.26	1.96	64.28
Pat white winter wheat flour.....	1.075	1.455	73.90
Patent flour.....	1.30	2.10	61.91
Patent flour.....	1.40	2.40	58.34
Pat Dog flour.....	.914	8.67	24.91

It is to be observed that in the red dog or lowest grade flour there is 50 per cent more total nitrogen than in the lowest grade of bakers' flour and nearly 90 per cent more than in the patent flour, but the gliadin nitrogen content of the red dog flour is only 24.91 per cent of the total nitrogen, while in the patent flour it is 63.09 per cent. The patent flour from soft wheat contained the highest proportion of gliadin of any of the samples. The dough made from this flour was very sticky and the bread was of poorer quality than that produced by the flour with a gluten containing 63.09 per cent gliadin. It would appear that the high per cent of gliadin was the cause of the sticky character of the dough.

In the examination of hard and soft wheats, reported in Bulletin No. 54, from this station, a marked difference in the gliadin to glutenin ratio was observed. The gluten from the best type of hard winter wheat contained approximately 60 per cent gliadin and 40 per cent glutenin, while the soft wheats contained a higher per cent of gliadin and a lower per cent of glutenin. The same general ratio of gliadin to glutenin is observed in the flours made from hard and soft wheat, the flours, however, contain a higher relative per cent of gliadin than the wheats.

In a high grade patent flour, made from Scotch (spring) wheat, the several proteids are present in about the following percentage amounts:

	Per Cent.
Albumin	0.3
Globulin	0.9
Proteose body	0.2
Gliadin	6.8
Glutenin	4.5
Total	12.7

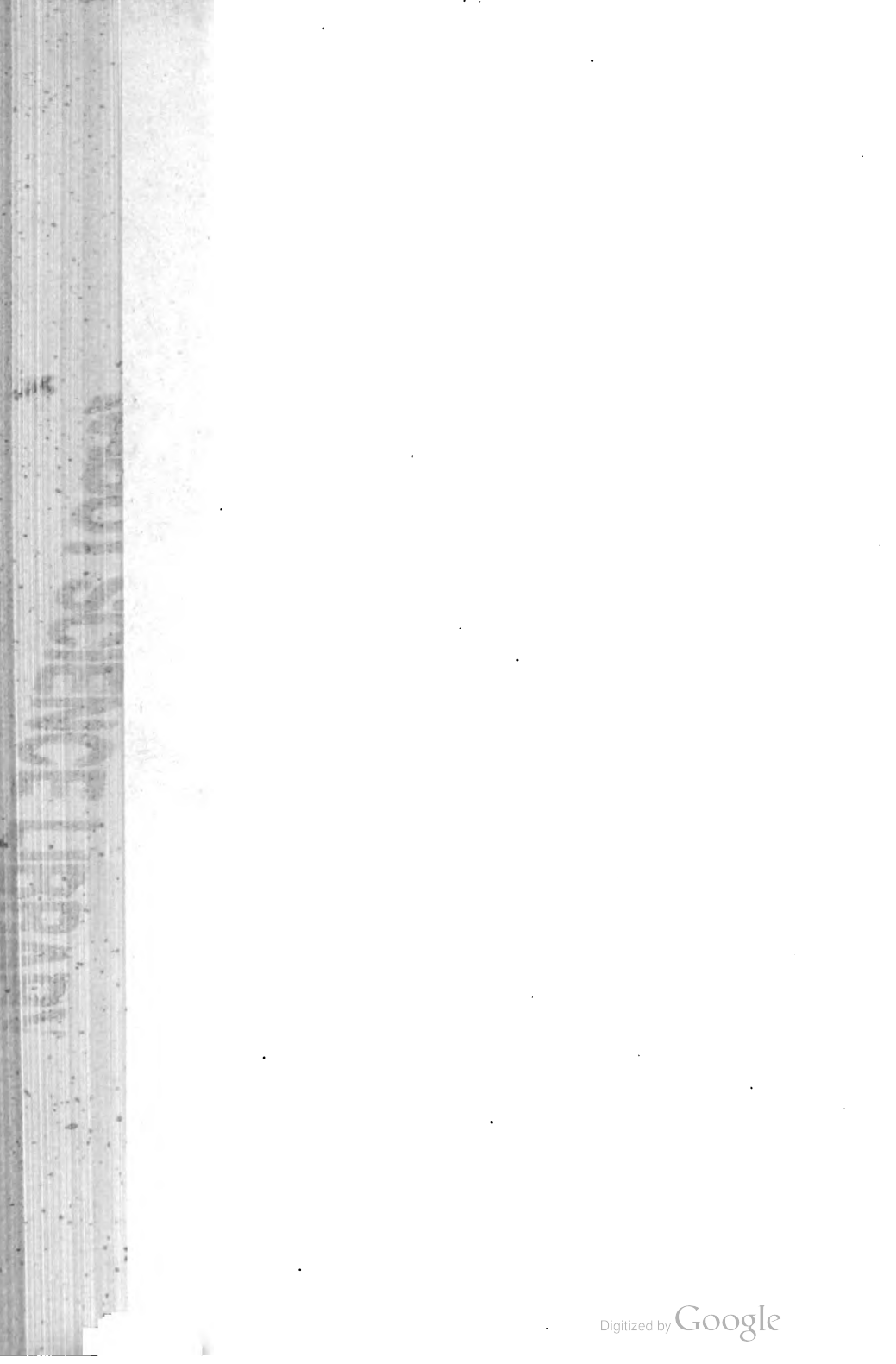
SUMMARY.

1. In the milling of wheat a partial mechanical separation of the various proteids takes place. The germ proteids are con-

posed largely of albumin and globulin bodies, while the bran and shorts contain only about 50 per cent of the total nitrogen in the form of gliadin and glutenin. The removal of the bran shorts and germ from the flour in the process of milling results in an increase in the gliadin-glutenin content of the flour, the non-gluten proteins being removed mainly in the offal products.

2. In the patent flour from soft winter wheat 73.90 per cent of the total nitrogen was in the form of gliadin, while in the patent flour made from hard winter wheat an average of 63.68 per cent of the total nitrogen was in the form of gliadin. The sticky character of the dough of the soft wheat was probably due to an excess of gliadin, and a deficient amount of glutenin. A well balanced gluten is composed approximately of 65 per cent gliadin and 35 per cent glutenin.

3. The gliadin-glutenin ratio in the different grades of flour made from the same wheat varies from 25 to 75 in the red dog, to 10 to 35 in the highest patent. The lower grades of flour contain appreciably more protein than the higher grades, but the gliadin and glutenin in the lower grades are not present in the right proportion to form a well balanced gluten, capable of expansion, and able to produce bread of the best physical properties.



UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

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ENTOMOLOGICAL DIVISION.

OCTOBER, 1899.

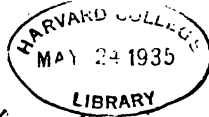
THE BLACK RUST OR SUMMER RUST.

THE HESSIAN FLY.

MIGRATORY LOCUSTS OR GRASSHOPPERS.

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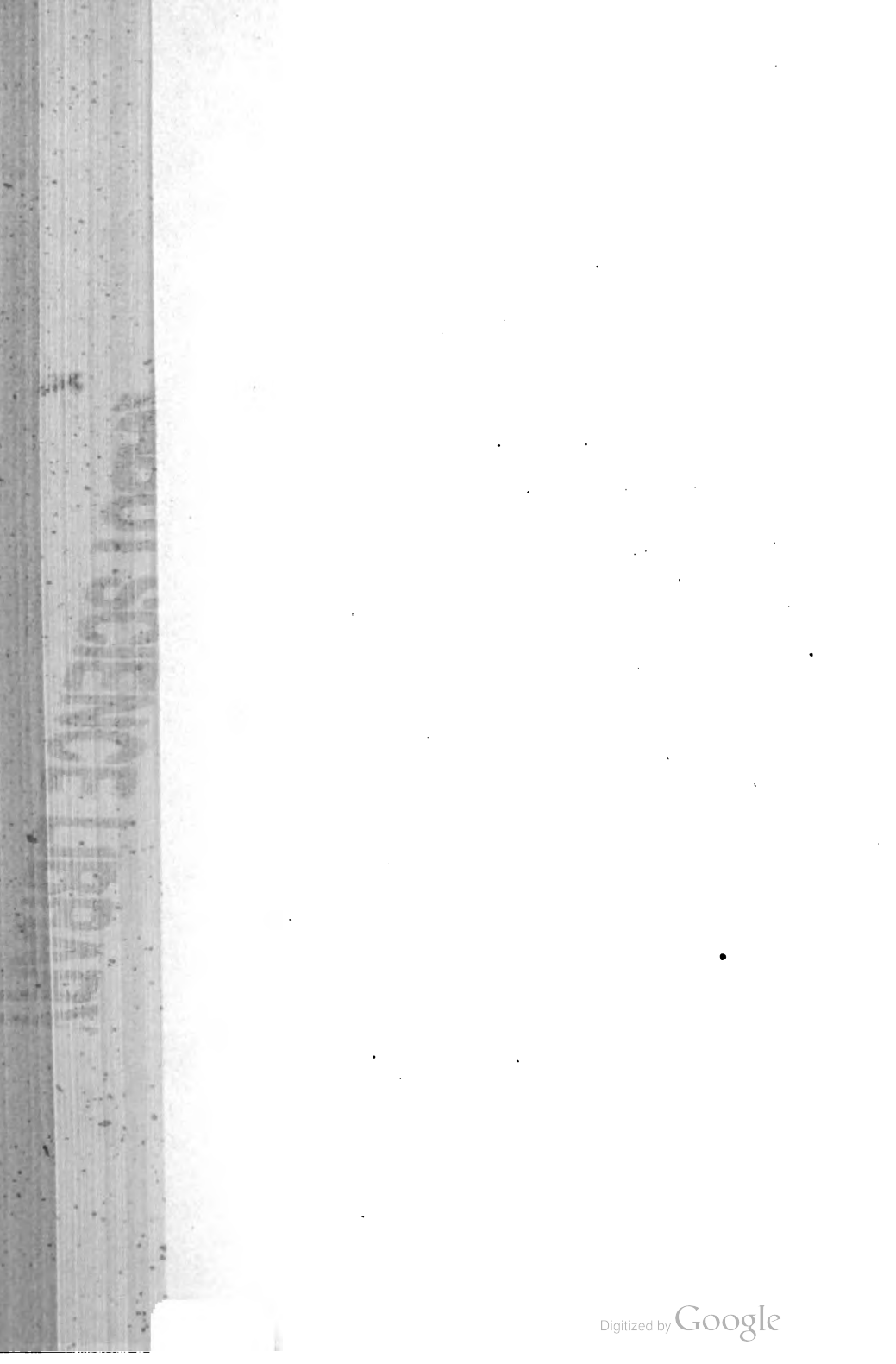
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INTRODUCTION.

Owing to the heavy losses to the grain in many sections of the state, caused by certain insects and vegetable diseases, and the fact that more and still heavier losses may be caused in the near future, unless farmers take time by the forelock and immediately go to work to at least partially prevent a repetition of them, the following bulletin has been prepared at the request of His Excellency, Governor John Lind, who has always taken deep interest in the welfare of the farmers of Minnesota, our true wealth producers. If the advice given in this bulletin is followed, and followed in time, much injury to our cereals may be avoided.

OTTO LUGGER,
Entomologist.



THE BLACK RUST OR SUMMER RUST.

OTTO LUGGER.

Our cultivated plants are frequently more or less injured by many different kinds of animals, insects, and parasitic plants or diseases. From time to time all these cause immense losses to the tillers of the soil, since they appropriate for their own use that which the farmer and gardener intended to use for himself, for his family, or for his stock. The farmer can see the larger of such intruders, and can fight them, frequently with good results. But such minute enemies as rusts, almost invisible as individual plants, but very prominent in the effect of their united work upon our small grains and grasses, he can not fight as well, nor can he greatly lessen the injury caused by their presence. In fact the great majority of our farmers do not even know or suspect that they have to fight against living organisms, against active, growing, and rapidly multiplying parasites; but they believe the rust to be simply caused by climatic conditions, by something indefinable in the air, or by some evil influence in the soil or water. They simply express their opinion by saying that the plants are sick; which is only too true, and sad experience tells them that such sickness will ruin their bright prospects for a rich return of their labors in the grain fields. *Rusts*, like the closely related *blights* and *smuts*, which are also caused by lowly organized vegetable organisms, truly blight the hopes of all farmers whose fields are invaded by them.

All those persons who had observed the promise of a big

yield of wheat on our fertile fields, so densely covered with the tall, golden-colored plants, waving in the bright July sunshine, did not suspect that in this case appearances could be so deceptive, but felt certain that a bountiful crop would be harvested. Yet many farmers have been sadly disappointed, for many heads of wheat are but poorly filled, or the kernels are not as perfectly plump as they should be to bring a good price. Whoever has experienced this unpleasant surprise, should know that the shrunken and shrivelled kernels are caused by the presence of rust, and especially by that of the *Black or Summer Rust*.

It is not necessary to enter into a detailed account of the three kinds of rusts that can become so injurious to our small grains, as all are very similar in their general appearance and their effects on the plants. All are parasites of the worst kind, and all abstract from the infested plants those substances that were taken from the soil by the latter to produce seeds.

The general belief that rust comes with rain after a very hot day is not wrong, only rain and hot air are not directly the cause of the trouble, but act simply as the carriers of it. Many experiments have shown that the minute bodies, or spores, causing the rust, are carried into the atmosphere from the infested plants by a current of air produced by the unequal expansion of the air by the sun. It will be seen that the air near the dark ground heats up quickly, and becoming lighter in consequence, rises, and in so doing carries with it the loosely attached spores of the parasitic rust. Such spores are really the seeds of the rust, called by another botanical term simply because they are produced in a different way than common seeds; yet they possess the same functions: they produce new plants. These spores are carried through the air by the upward current, and if they reach a certain altitude they may float during the day for hundreds of miles. Like balloons, they are so light that they are at the mercy of every current, nor do they descend so long as there is still a current of air rising from the ground. They can not return to mother Earth until evening, when they descend with the heavier humid air, and with the dew. Of course if it should rain during the day the

are brought down again with most of the other floating impurities in the air. If it should rain hard they are brought down to the very ground, and leaves of grain coated with them are washed clean. This is a bad thing for the spores, but a very fortunate occurrence for the owner of the plants, as such spores are lost forever, or, what is as good, are unable to cause further trouble. As they come in contact with the moist soil they soon germinate, and not having a chance to reach the green leaves or stems of wheat, etc., they perish in a very few hours.

A heavy rain following a hot day is therefore of benefit to the farmer and injurious to the parasite. But if moisture comes down as a fine mist, or during the night as a heavy dew, then the spores reach the leaves and stem of the host, i. e., the invaded plant, and, being surrounded by moisture and warmth, they soon sprout and enter the plant.

It is frequently said that certain fields are worse infested than others, and sometimes an explanation is difficult to find. But when we recollect that on a very warm day, without any wind, the spores are simply carried upwards, and during the night downwards, we may find an explanation for the fact that rust is always worse behind wind-breaks and other shelters than anywhere else, simply because in such places the air is stagnant, and all the spores produced there are only too apt to lodge again upon grain planted in such sheltered places. Rank plants, caused by manure or by any other means, are also quite frequently injured more than the drier plants growing elsewhere, for very self-evident reasons. Grain planted early, with a moderate amount of foliage, usually escapes to a large extent the rust, while neighboring fields with a more rank growth will suffer.

As this bulletin is intended for general distribution among farmers and others interested in agriculture, or to people possessing all degrees of botanical knowledge, it is rather difficult to treat this subject in a popular way. In describing *fungi*, a family of plants to which rusts, smuts, blights, etc., belong, we must necessarily use some botanical terms, because the English language, though so rich in words, does not possess any to denom-

inate the parts and organs of such lowly organized and microscopic plants, for the simple reason that it was formed long before the existence of any extensive botanical science. But the writer will endeavor to make the description as plain as possible and the illustrations will go far to assist the reader in understanding them. The illustrations are, in part, taken from a book by W. G. Smith, entitled "Diseases of Field and Garden Crops."

Rust is a parasitic plant which enters the *host*, or infests a plant, and there causes disease. It is carried by wind and rain but not caused by either. To show how the spores of rust look or how they enter the hosts, figures 1 and 2 are given. Fig. 1, enlarged 1,000 times, shows two summer spores (uredospores) one in the act of sprouting.

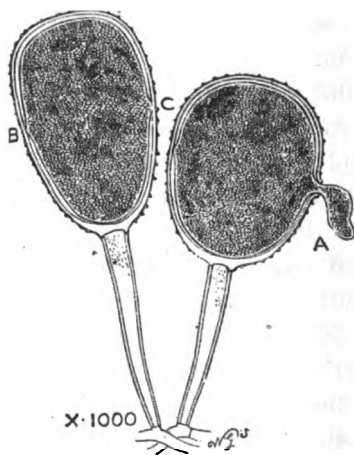


FIG. 1. Uredospores in the act of sprouting. Enlarged 1000 diameters.

This operation can be studied by keeping such spores in moist air for a few hours. Germination takes place by the protrusion of two germ tubes or threads of mycelium, one from each side and usually near the middle, though sometimes from or near the top of the spore. The spots whence the tubes emerge from the

spores can often be detected even before germination, as here the walls are weak, as can be seen at B and C. At A one of the tubes has broken through the walls.

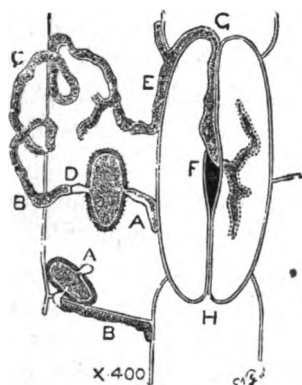


FIG. 2. Two summer spores (*uredospores*) growing upon a bit of leaf. Enlarged 400 diameters.

In Fig. 2 we see two summer spores (*uredospores*), enlarged 400 times, growing upon a bit of leaf of wheat. As a very general rule only one of the germ tubes grows, while the second one, as seen at AA, remains short or inactive. The larger and stronger tube keeps on growing in a convoluted fashion, as at C, and in a day, or a day and a night, it has attained many times the length of the spore from which it grew, and which is now entirely empty and falls to the ground. But before this happens a partition, or *septum*, has formed, as at D, which separates the living from the dead tissue. When we carefully watch one of these slender germ tubes under a microscope, we shall be greatly surprised, as it now looks like a living worm, and it moves or flows into any little scratch or depression on the glass. Now, why should it do so? When we study the structure of a wheat leaf we will at once find an explanation. We find that it is the aim of this tube to enter into the tissue of the leaf, and this it can not do unless there is an opening provided for this purpose. And there are many such openings, namely the minute mouths of a leaf, organs

of transpiration, called "*stomata*." One of them is shown at B, and it will be seen that the tube follows the depression E, and when this opening is reached. Such stomata are the lowest points on a leaf surface; hence the germ tube can not fail to reach them. One of these worm-like tubes enters, and soon disappears from sight (see dotted outline). Once inside, it branches out right and left, and soon ramifies amongst the green cells. Here it produces a plant called a "*mycelium*," composed simply of fine, delicate threads. In a short time it produces large numbers of new summer spores (*uredospores*), which break through the wheat cuticle a short time afterwards, and on reaching the surface form the well known rusty-brown pustules. The mycelium has a brownish color, and is shown in Fig. 3, between the cells of the wheat leaf at C, and the spores. The latter try to force their way through the three mouths or organs of transpiration at A, B, and at D, D. This illustration, which is a transverse section through the rusty-brown pustule (or *sorus*), also shows the closely packed summer spores (*uredospores*). These are supported upon transparent pedicles or stems, as can be seen in

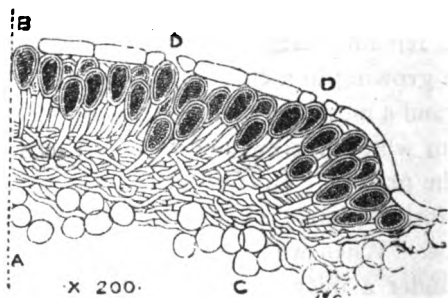


FIG. 3. Transverse section through half a pustule or sorus. Enlarged diameters.

1 and 3. The spores in a sorus vary to some extent in shape and size, no two are exactly alike; still they vary only within well defined limits.

Early in summer leaves of the wheat plant infested with the parasites show rusty-brown spots: the pustules or sori. Fig.

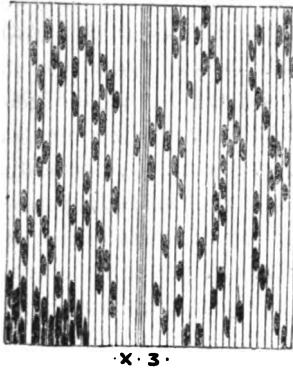


FIG. 4. Fragment of wheat leaf invaded by rust. Enlarged 3 diameters.

shows a small piece of such a leaf enlarged three diameters, and in Fig. 5 we see one of the pustules still more enlarged. Here we find that the skin is ruptured, and that immense numbers of sum-

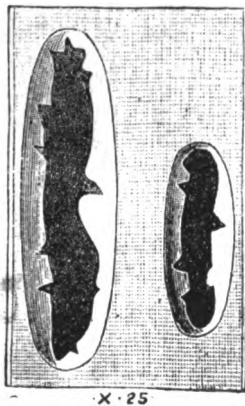


FIG. 5. Pustules or sori. Enlarged 25 diameters.

mer spores are crowded together, waiting to be torn off by the wind and to be carried to other and still uninfested parts of the same or other wheat plants.

One generation of summer spores (uredospores) follows the other, and as long as the infested wheat plant can still furnish

liquid food there is no cessation. Sometimes very heavy and peated rains will improve conditions very materially, as they apt to wash off all the exposed spores, and thus make them harmless. Of course more moisture will also produce fresh and infested new foliage on the top of the plants. The writer even seen that the army-worms, by no means desirable visitors to our grain fields, were actually of benefit, as they devoured leaves, rust and all, and thus materially assisted the plants to rid of these parasitic vegetable intruders.

As the wheat plants ripen and become dry, no longer furnishing liquid food, the parasitic rust-plant is also forced to

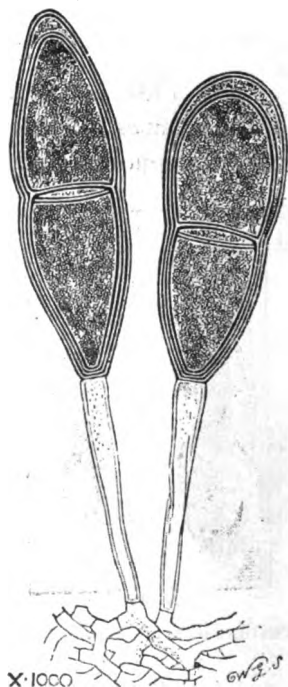


FIG. 6. Winter spores or Teleutospores. Enlarged 1000 diameters.

operations for the summer. This it does by producing different kinds of spores, the winter spores or teleutospores, two of w

are shown in Fig. 6. By comparing Fig. 1 and Fig. 6 we can at once see a great difference between these two kinds of spores, and it is hardly necessary to draw the attention of the reader to them. Not alone do they differ in size, but it will be seen that the winter spores are always united in twos. Besides, they are very much darker, possessing heavier coats than the summer spores, and for good reasons, as the parasites have to hibernate in this shape.

A transverse section through half a pustule or sorus, as found late in the season, shows the winter spores also crowded together, ready to force their way through the ruptured skin. These spores possess larger stems. Such a section is shown in Fig. 7.

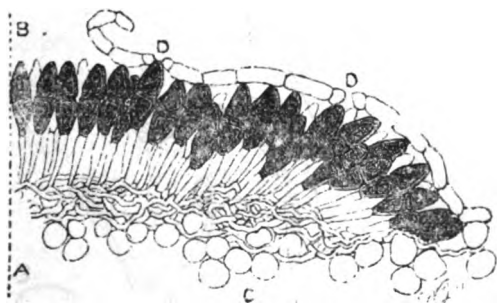


FIG. 7. Transverse section through half a pustule or sorus, showing the winter spores. Enlarged 200 diameters.

Now what becomes of these winter spores or teleutospores? We know that they are well protected against the cold by double coats of thick skins, that they are not killed by frost, and that they will readily germinate the next spring. We also know that there are now untold millions of winter spores upon the dead leaves and stems of all kinds of small grains and grasses in the infested regions, and if these spores could again invade the healthy young plants the next spring, it would be folly to expect any of the latter to thrive, since they would soon be invaded by the parasites and be destroyed. This would be a sad state of affairs, and farming would soon have to cease. For these reasons it is important for our farmers to know exactly what they have to expect, and so let

us follow the life-history of these destructive plants still further. We shall see that the parasites have an immense power of destructiveness, but that there is also a limit to their continuous increase. Their life-history is very similar to that of many low organized animal parasites, for instance to that of the nasty tapeworms, which have to pass through other animals, and through an entirely different form, before they can again appear as tapeworms in the human being. We know that the winter spores are not killed by frost, but we also know that they can not again enter the tissues of grains and grasses, but that they have to

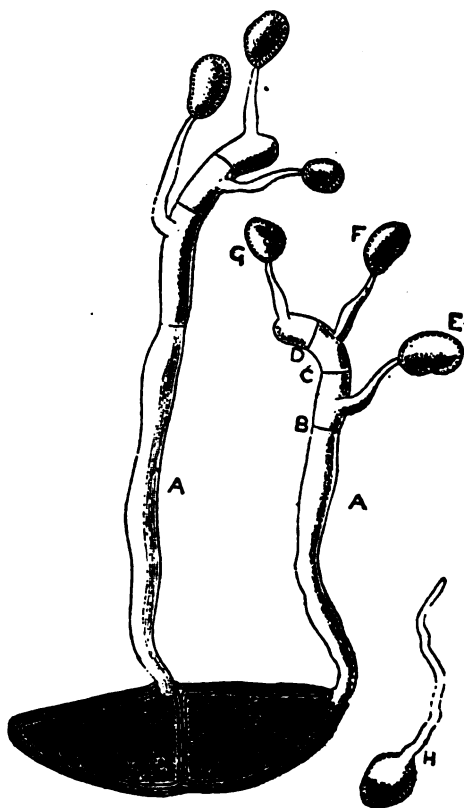


FIG. 8. Winter spores (Teleutospores) germinating in spring. Enlarged diameters.

through another plant, in which they produce an entirely different disease, before they can again become destructive to our main staples, the cereals and grasses.

If during the spring we take a small knife or a needle and remove some of the black spores found in the pustules of the invaded straw, and place them in a film of water on a slide under a thin cover-glass, and keep this in moist air under a bell-jar, to prevent evaporation, we can observe that germination usually takes place by the protrusion of a thread from each of the two cells of the winter spore. In Fig. 8 we can see the whole operation. These two threads, the first produced in spring, are called the *pro-mycelium*, or the first mycelium. They are the beginning of the cycle which has for its last form the winter spores or teleutospores. The pro-mycelium is seen at AA. It does not grow to any great length, but after attaining three to four times the length of the black winter spore, it usually coils round somewhat like a shepherd's crook. It produces about three stops, joints, or *septa*, as at B, C, D, and from each of these three separate pieces a fine branch is produced; each bears an irregular, oval, transparent and very pale amber-colored spore at its end, as shown in E, F, G. These are the third kind of spores we have found, as we have already had the rusty-brown summer spores (uredospores), the blackish winter spores (teleutospores), and lastly, the amber-colored spring spores (pro-mycelium spores). These latter germinate very readily in a film of water on a glass, as illustrated at H, and produce a fine tube of mycelium.

In nature the black winter spores germinate upon straw as it decays on the ground in spring, and the minute, ovoid, pale amber-colored spores are carried about in the air in millions. But—and this is the most important fact to know—they can not enter into the tissues of cereals and grasses, but have to pass through those of another plant, a plant luckily not growing wild in our state, and only cultivated here and there for the sake of ornament and the berries it produces. The spring spores will only grow in the barberry and some allied plants. This has been proved over and over again. At least up to the present time no

other plants, and certainly not cereals and grasses, are known in which the spores can grow.

As soon as such spores reach the leaf of a barberry plant they sink into it through the cells of the epidermis to the bottom of the leaf. *They do not pass through the mouths or stomata.* In the leaf they produce a fungus of an apparently entirely different character from that on the wheat, viz., the Barberry Blight (*Æcidium berberidis*) shown in Fig. 9.



FIG. 9. Barberry leaves invaded by *Æcidium berberidis*. Actual size.

The Barberry Blight is very common upon this plant wherever it is grown in Minnesota. The parasitic *æcidium* almost invariably grows on the under surface of the leaves, although it is sometimes also found on both sides, in fact upon all parts of the plant. It is shown in Fig. 9 at *A, A, A*, where it forms clusters or groups of little sulphur-colored spots imbedded in dark red swollen patches. If we study the upper surface of the leaves, we find similar patches more or less covered with little black dots termed *spermogones*. These are shown at *B, B, B*. These *spermogones* also occur, but only rarely, upon the lower surface. Each of them is very much smaller than the point of a pin, and on this account they are easily overlooked; they usually appear before the *æcidium* cups. If we study both with a strong magnifying lens the

spermogones still look like small black spots, but if we observe the æcidium clusters we see companies of beautiful sulphur-yellow cups bursting open through the lower surface of the leaf, and each cup is filled with a yellow powder resembling small yellow grain. To understand clearly the nature of these cups or of the black spermogone spots it is necessary to cut a section through the barberry leaf, as in Fig. 10. A represents the lower, B the

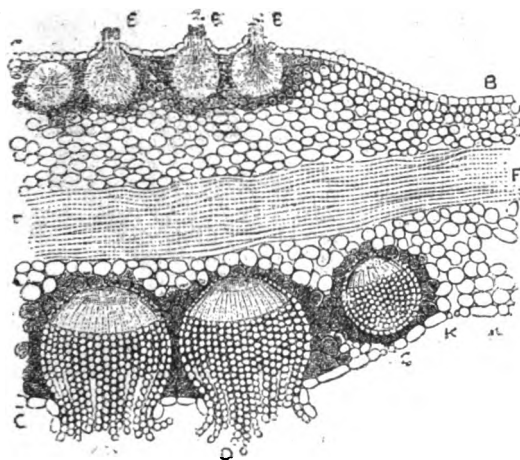


FIG. 10. Section through a barberry leaf, showing the cups below and the spermogones above. Enlarged 50 diameters.

upper surface of the leaf, at C one of the little cups is still buried in the tissues of the leaf. At DD two of the mature cups are shown, and at EEE three black spermogones; leaves invaded by this fungus are greatly thickened, as may be seen at GH. If we enlarge such a section still more we can observe the details, still better shown in figs. 11 and 12. In fig. 11 a section through a cup of *æcidium berberidis* is shown. The lower skin at B is ruptured by the fungus from within at CD. The fine, almost granular mycelium from which the fungus springs is shown at the top at D. It creeps amongst the intercellular spaces at E. The outer coat of the cup, consisting of a single layer of transparent, five-sided cells, is shown at FF, and the sulphur-yellow spores

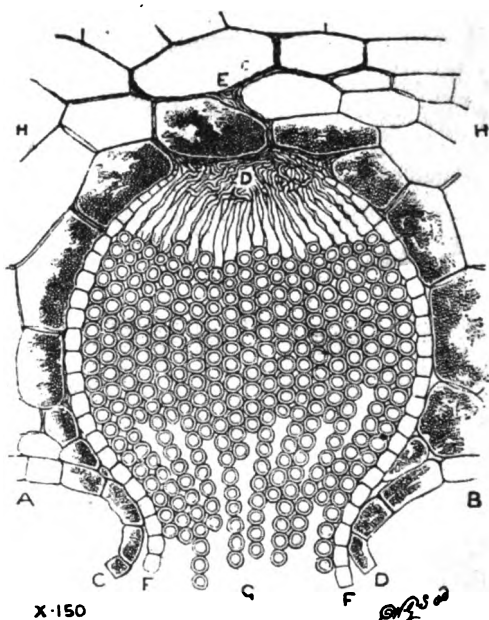


FIG. 11. Section through a cup of *Ascidium berberidis*. Enlarged 150 diameters.

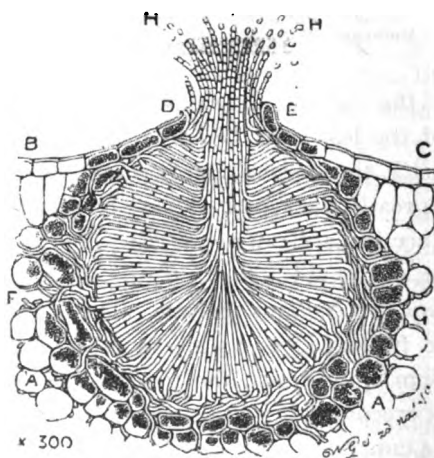


FIG. 12. Section through a *Spermogonium*. Enlarged 300 diameters.

hanging in chains from the open cup, at G. These spores drop as soon as ripe, and others, which are continuously produced, take their places.

A similar action takes place in the spermogonia upon the upper surface of the leaf. Here the mycelium gradually approaches the upper surface through the intercellular spaces. When near the surface it forms minute knots, similar to the cups upon the under surface of the leaf, but differing in an important particular, i. e., the æcidium cup grows from the base of the spermogonium by a constant protrusion of new threads from the circumference to the center. The spermogonium, which means a flask or case containing *spermatia*, contains large numbers of these extremely minute bodies, which possess the functions of pollen in higher organized flowers. A ripe spermogonium is shown in Fig. 12, and a single æcidium spore in Fig. 13. Attached to it are four sperm-

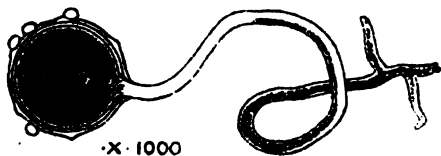


FIG. 13. Germinating spores of *Æcidium Berberidis*. Enlarged 1000 diameters.

matia from the spermogones. They are the male element, and are grains similar to the pollen which we find so frequently glued to a stigma. These spores grow rather slowly by protruding a mycelial thread in a convoluted fashion from one of about six weak spaces on the surface of the spore; in this mycelial thread the vital material of the spore enters, leaving the latter dry and empty.

In ancient times diseases caused by rust seem to have been widely distributed and to have caused great losses. They were consequently much feared, and as they stood under the special protection of two deities, Robigus and Robigo, festivals were held to pacify them so that they would avert the disease. Such festivals were called Robigalia. A modern, and no doubt more

successful way to partly prevent injuries caused by rusts, but especially by the Black Rust or Summer Rust, is to prevent the latter from wintering in our state. And to do so is not very difficult. All that is necessary is to permit no barberry to grow anywhere near the grain fields. The experience of last season has clearly demonstrated the fact that barberries communicate the Black Rust to the wheat, and that neighborhoods in which these plants are permitted to grow are always badly infested by this disease, more than any other place, and that the disease spreads from such centers to the whole region. By destroying such breeding places of the Black Rust we do not entirely prevent this disease, but our fields will not be infested by it early in the season, and only much later from spores coming with the wind from the south. Every farmer should insist upon this: *Never permit barberries to grow near a grain field.*

THE HESSIAN FLY.

OTTO LUGGER.

This destructive insect has again caused considerable losses to the farmers of Minnesota, and seems to have found a permanent home in the western counties, extending from Jackson, Cottonwood and Pipestone counties in the south to the entire Red River Valley in the north. Even parts of Manitoba have been invaded. It has been especially injurious in the Red River Valley, causing losses from 5 to 25 per cent on many farms. A large area is again badly infested, and, what is worse, there seem to be but very few parasites to assist us against this enemy. It seems that the abundant rains early in spring assisted this insect very materially, as it is a being that loves cold and wet seasons, and not like the equally destructive chinch bug, dryness and warmth. The damage in many places was quite serious, and close attention on the part of farmers is required to prevent still more serious losses in the future.

The history of the Hessian Fly (*Cecidomyia destructor* Say) in more southern and eastern regions of the United States is briefly as follows: There are ordinarily two broods or generations, which appear during May and June, and later during September and October. The fly is a small, two-winged insect, resembling somewhat a mosquito, dusky in color, and about one-eighth of an inch in length. The male is very slender, and the female, when ready to deposit her eggs, a little stouter. The eggs, oval and bluntly pointed at each end, are about one-fiftieth

of an inch long, and of a dull reddish color. They are singly, or two or three in a cluster, on the upper surface of a seed. Some years ago a female fly, just leaving the puparium, was dissected, and 238 eggs were found in her, which show how rapidly this pest can increase if conditions are favorable. As soon as the young white maggot hatches, it goes its way downward inside the sheaths to feed upon the succulent tissue at the base of the stalk. In the autumn they usually go beneath the surface of the soil, but in the spring more often stop just above the surface, at or near the lower joints. The larvæ, or maggots, feed there until ready to change to the puparium flax seed stage, which is assumed between the sheath and the stem. The flax seed stage takes its name from the great resemblance between the puparium and the seed of flax in size, color, and form. This little seed-like object is nothing but the old body of the maggot shrunk, hardened and colored brown; it contains the true pupa, from which issues the perfect fly at the periods mentioned before. The presence of the puparium "flax-seed," can usually be detected by the breaking down of the stem at the point where it is found. This breaking down is due to the weakening of the stem, which has its interior partly destroyed by the maggot; and as this takes place at about the time that the ear of wheat forms, and before harvest, nearly all the infested stalks remain on the ground, not being cut by the reaper orvester; and the presence of the fly is at this time noticed even by non-observant farmers. As the maggots and the flax-seed are not readily detected except by a careful search with a spade, the numerous uncut straws upon the ground are frequently complained by the occurrence of a slight hailstorm, lack of seed in the straw, too much moisture, or by what not.

The different stages of the Hessian fly are shown in Fig. 1.

The insect is double brooded in more southern places, so that there may be adult individuals found at any time between the two broods, not, however, in great numbers. Such individuals are found in wheat sown out of season, or else in volunteer wheat.

In more southern states the following remedies are of

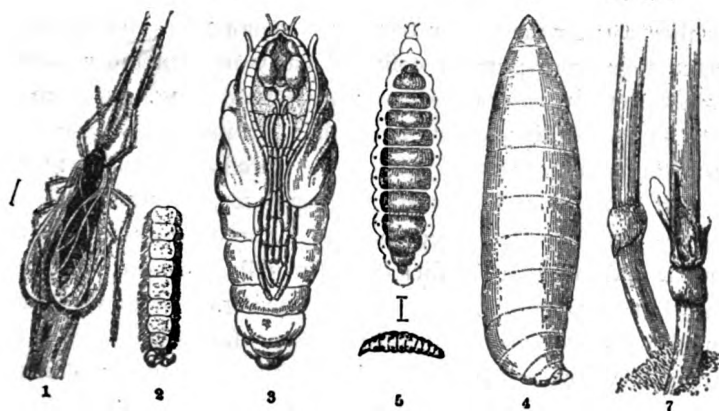


FIG. 14. Hessian Fly. 1, adult female; 2, male abdomen; 3, pupa removed from flax seed; 4, flax seed; 5, larva or maggot; 7, flaxseed in position. All enlarged with the exception of 7.

They are here simply given as furnishing suggestions to our farmers:

Late Sowing of Fall Wheat—This furnishes the fall brood, which issues in September and early October, nothing upon which to deposit its eggs, or if deposited, it is too late for the larvae to burrow to a safe place in the stem to pass the winter.

Burning the Stubbles has been found to destroy many of the maggots and the "flax-seeds."

Rotation of Crops often leaves the adults without wheat plants in which to deposit eggs, so that when wheat is again sown the flies are all dead in that vicinity. It is a process of starving them out.

Pasturing Early Sown Wheat in the Fall is likely to destroy large numbers of maggots and "flax-seeds."

The Hessian Fly is now common almost throughout the western portion of our state, and not alone in the more southern counties, where both winter and spring wheat is grown. It is most abundant, however, in the Red River Valley, where only spring wheat is grown, and it is difficult to understand how this insect can exist under such conditions. If it was single-brooded

an explanation would be simple, and it almost seems as if that was the case, as the writer has thus far not been able to obtain winged flies from puparia collected early in September, with a single exception, as one Hessian-fly issued Aug. 22 from infested straw obtained from St. Haire, Minn. Immense numbers of puparia from many parts of the state have been kept under the most suitable conditions in breeding-cages, glasses, boxes, etc., yet only one fly issued, besides numerous parasites. This seems to indicate that the flies do not usually issue during the autumn, but remain in the straw until spring. Another observation, though not a proof that there is no fall brood, is the fact that no larvæ or puparia could be found in volunteer plants of wheat growing near fields which had been badly infested.

It is very important to know in what condition the Hessian fly winters. If in the "flax-seed" stage, which seems to be the case, then a remedy is very simple and inexpensive. The insect being found in the first joint of the stem, or very near it, is in that portion of the plant that remains in the stubble field, or is not carried away in the bundles. Hence the insect can be destroyed with the stubbles. In some cases it is possible, by cutting the plants in such a manner that combustible material is left, to burn over the field, and thus destroy all the intruders. But this can not be done *plowing* is an excellent remedy. This should be done as soon as possible after harvesting. The flies, even if they should issue during September or October, can not reach the surface of the plowed fields, as they are weak and unable to penetrate a thickness of several inches of soil. They are kept prisoners and have to perish. The parasites, however, which may be found in some of the puparia, have but little difficulty of escaping, hence plowing at the proper time, i. e. soon after harvesting, will destroy our enemies and protect our friends.

The Hessian fly is the prey of many parasites, and in 1878 when this noxious insect first caused serious injury in Minnesota these beneficial insects helped to such an extent as to almost stamp out the intruders. The many specimens of infested straw received this autumn do not reveal the presence of many parasites.

and only straw obtained from near Crookston contained some. Of course more parasites will be at work than could be decided from the material received, but the outlook is by no means as hopeful as it was in 1896; hence farmers should not depend upon the assistance of parasites, but should assist themselves by plowing all stubble fields as soon as ever they can, and especially those that they know contained Hessian flies and Frit flies.

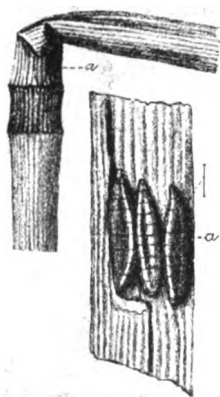


FIG. 15. Hessian Fly. At the right, three puparia (a) exposed; at the left, puparium (a) and the manner in which straws bend and break. Enlarged. Original.

As many farmers have never seen the "flax-seeds" the illustration (Fig. 15) has been prepared, which will assist them to detect their hidden foe.

In the following illustrations those parasites are shown which are at present most numerous and of great assistance. They are all very minute, and not apt to be seen. But those interested in such matters can easily decide for themselves whether such parasites are present or not. All they have to do is to keep a few pieces of straws containing the "flax-seeds" of the Hessian flies in a bottle. If parasites are present they soon show themselves by eating round holes from the infested flax-seeds to the outside of the straws, and they can be seen as dark and very active minute

objects, constantly running about as if in search of new enemies to conquer.

Three different species of parasites have been observed so far. Two of the adult parasites are shown in the illustrations.



FIG. 16. Female of *Merisus destructor*, Lag. Enlarged. Original.

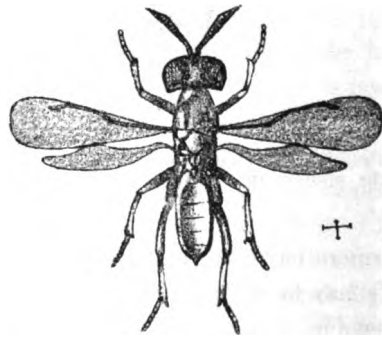


FIG. 17. Male of *Eupelmus Allynii*, French. Enlarged. Original.

Fig. 16 represents a female of the most common parasite (*Merisus destructor* Say), and Fig. 17 the male of *Eupelmus Allynii* (French). The female of the latter occurs both with and without wings. A third parasite (*Polygnotus hiemalis* Forbes) was also raised. It is very small, and six of these minute beings found sufficient food to pass through all their metamorphoses in a puparium of the Hessian fly. In Fig. 18 is shown the brood



FIG. 18. Puparium of Hessian fly, with six cocoons of a parasite. Enlarged. original.

ulm, the puparium of the Hessian fly, and the six small cocoons of this minute parasite still fastened to it.

MIGRATORY LOCUSTS OR GRASSHOPPERS.

OTTO LUGGER.

It is well known to all farmers and others engaged in growing grain, vegetables and fruit, that locusts are among the worst enemies they have to combat, and especially the migratory kind. These usually occur in vast armies. Our state is so situated that armies of such devouring insects can be expected from time to time, and it is well to be always prepared for such a visit. This is especially true at this time, when two of the worst kinds, the Rocky Mountain Locust (*Melanoplus spretus*, Uhl.) and the Lesser Green Migratory Locust (*Melanoplus atlantis*, Ril.), have already reached our state in small swarms. The former, if not actually introduced into the state in large numbers, is very close to it. The latter is distributed over many portions of the state and a third, the *Campestris pellucida* Scudder, seems to be also coming from the North. None of them have as yet caused much damage to our crops, but they may do so next year if no steps are taken to prevent it. Many of our common native species have also become very numerous, and have caused considerable damage in isolated cases.

In the First Annual Report of the U. S. Entomological Commission we can find an excellent description of the destructive power of locusts, and many of our farmers know to their cost how correct this description is. No one who has not witnessed the ravaging power of locusts can fully conceive of or appreciate it. The organization and habit of the typical locust admirably adapted for ravenous work. Muscular, gregarious, with powerful jaws

and ample digestive and reproductive systems; strong of wing and assisted in flight by numerous air sacs that buoy—all these traits conspire to make it the terrible engine of destruction which history shows it to have been under conditions favorable to its excessive multiplication. Insignificant individually but mighty collectively, locusts fall upon a country like a plague or a blight. The farmer plows and plants. He cultivates in hope, watching his growing grain, in graceful, wave-like motion wafted to and fro by the warm summer winds. The green begins to golden; the harvest is at hand. Joy lightens his labor as the fruit of past toil is about to be realized. The day breaks with a smiling sun that sends his ripening rays through laden orchards and promising fields. Kine and stock of every sort are sleek with plenty, and all the earth seems glad. The day grows. Suddenly the sun's face is darkened, and clouds obscure the sky. The joy of the morn gives way to ominous fear. The day closes, and ravenous locust-swarms have fallen upon the land. The morrow comes, and oh! what a change it brings! The fertile land of promise and plenty has become a desolate waste, and old Sol, even at his brightest, shines sadly through an atmosphere alive with myriads of glittering insects. Falling upon a cornfield, the insects convert in a few hours the green and promising acres into a desolate stretch of bare, spindling stalks and stubs. Covering each hill by hundreds; scrambling from row to row like a lot of young famished pigs let out to their trough; insignificant individually, but mighty collectively, they sweep clean a field quicker than would a whole herd of hungry steers. Imagine hundreds of square miles covered with such a ravenous horde, and one can get some realization of the picture presented in many parts of the country west of the Mississippi during years of locust invasions. Their flight may be likened to an immense snow-storm, extending from the ground to a height at which our visual organs perceive them only as minute, darting scintillations, leaving the imagination to picture them indefinite distances beyond. It is a vast cloud of animated specks, glittering against the sun. On the horizon they often appear as a dust tornado, riding upon

the wind like an ominous hail storm, eddying and whirling about like the wild, dead leaves in an autumn storm, and finally sweeping up, to, and past you with a power that is irresistible. They move mainly with the wind, and when there is no wind they whirl about in the air like swarming bees. If a passing swarm suddenly meets with a change in the atmosphere, such as the approach of a thunder storm or a gale of wind, they come down precipitately, seeming to fold their wings, and fall by the force of gravity. At other times, in alighting, they circle in myriads about you, beating against everything animate or inanimate, driving into open doors and windows; heaping about your feet and around your buildings; their jaws constantly at work biting and testing all things in seeking what they can devour. In the midst of the incessant buzz and noise which such a flight produces, in the face of the unavoidable destruction everywhere going on, one is bewildered and awed at the collective power of the ravaging host, which calls to mind so forcibly the plagues of Egypt. The noise their myriad jaws make when engaged in their work of destruction can be realized by any one who has fought a prairie fire, or heard the flames passing along before a brisk wind, the low crackling and rasping—the general effect of the two sounds is very much the same. Nothing, however, can surpass the prophet Joel's account of the appearance and ravages of these insects.

“Onward they come, a dark, continuous cloud
Of congregated myriads numberless,
The rushing of whose wings was as the sound
Of a broad river, headlong in its course
Plunged from a mountain summit, or the roar
Of a wild ocean in the autumn storm,
Shattering its billows on a shore of rocks.”

—*Southey.*

As a full account of the three species has been given in number of bulletins, some of which can still be had by applying for them at the office of the Experiment Station in St. Anthony.

Park, it is not necessary to repeat it here. The three kinds, as well as two of our most common and destructive native kinds, have been illustrated in Plates III and IV, as well as in the text, so that a little study of these illustrations will enable our farmers to make certain which of these enemies they have to combat.

At the present time only one remedy can be applied, which depends entirely upon the way in which these locusts deposit their eggs, and for this reason a chapter printed in the 3rd Annual Report of the Entomologist is repeated.

HOW LOCUSTS DEPOSIT THEIR EGGS.

It is very important to know the manner and localities in which eggs are laid by the different kinds of locusts, because the only true and always successful remedy depends almost entirely upon this knowledge. In former papers the method of laying eggs by the Rocky Mountain Locust was discussed, but it is best to repeat and enlarge upon what was written at that time. The following figures will illustrate the method of egg-laying better than words. The holes for the reception of the eggs are made by means of two pairs of horny valves at the tip of the

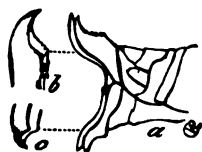


FIG. 20.—Rocky Mountain Locust—*a*, anal characters of female showing horny valves, *b*, and *c*. (After Riley).

abdomen of the female (Fig. 20, *b* and *c*). These open and shut rapidly, and are well adapted to execute this function. The female, pressing the tip of her abdomen forcibly against the soil, rapidly opens and shuts these hard and pointed valves, and soon pushes them into the ground, thus drilling a hole. Fig. 21 illustrates this action, and the various positions assumed by the females are plainly indicated. In a short time nearly the entire

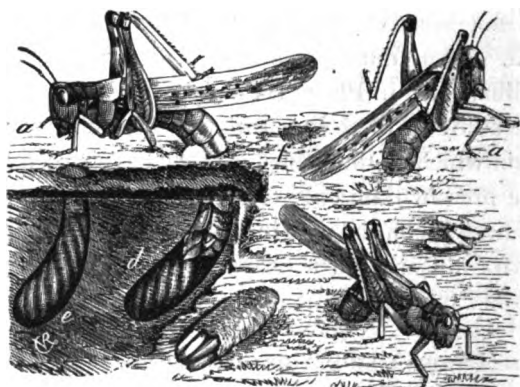


FIG. 21.—Rocky Mountain Locust, in the act of laying eggs. (After Riley)

and greatly extended abdomen is inserted in a little curved more or less oblique cavity. The legs are hoisted above the during the operation of drilling this hole, which requires more or less time, depending entirely upon the condition and character of the soil. As soon as the hole is finished, it is filled with a frothy and mucous material. Professor Riley, in describing the method of laying eggs, writes: "By repeatedly retracting and studying specimens in every stage of oviposition we have been able to ascertain the exact method by which the egg-mass is formed. If we could manage to watch a female from the time the bottom of her hole is moistened by the secretory fluid, we should see the valves all brought together, where the egg would pass down the oviduct along the ventral side, guided by a little finger-like style, pass in between the hind valves, and issue at their tips amid the mucuous fluid already spoken of. Then follows a period of convulsions during which more mucous material is elaborated, until the whole end of the body is bathed in it, when another egg passes down and is placed in position. These alternate processes continue until the complement of eggs are in place, the number ranging from twenty to thirty-five, but averaging about twenty-eight. The mucous matter binds all the eggs in a mass, and when the mass is laid, the mother devotes some time to filling up the soil

what narrower neck of the burrow with a compact and cellular mass of the same material, which, though light and easily penetrated, is more or less impervious to water, and forms a very excellent protection. When fresh the mass is soft and moist, but it soon acquires a firm consistency."

To a casual observer the eggs of our locust appear to be thrust indiscriminately into the hole made for their reception. A more careful study of the egg-mass, or egg-pod, will show, however, that the female took great pains to arrange them, not only so as to economize as much space as possible, consistent with the form of each egg, but so as to best facilitate the escape of the young locust; for if, from whatever cause, the upper eggs should fail to hatch, or should hatch later than the lower ones, the former would offer an impediment to the exit of the young in their endeavor to escape from these last, were there no provision against such a possibility. The eggs are, indeed, most carefully placed side by side in four rows, each row containing seven. They oblique a little cross-wise of the cylinder (Fig. 22, *a*). The posterior, or narrow end, which issues first

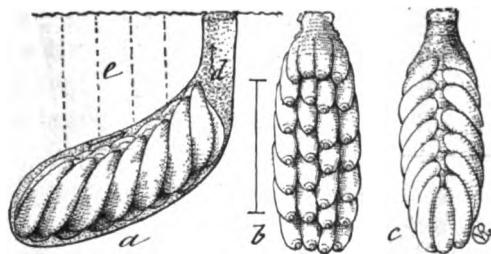


FIG. 22.—Egg-mass of Rocky Mountain Locust—*a*, from the side, within burrow; *b*, from beneath; *c*, from above; enlarged. (After Riley).

from the oviduct, is thickened and generally shows two pale rings around the darker tip (Fig. 22, *b*). This is pushed close against the bottom of the burrow, which, being cylindrical, does not permit the outer or two side rows to be pushed quite as far down as the two inner rows, and for the very same reason the upper or head ends of the outer rows are necessarily bent to the

same extent over the inner rows, the eggs when laid are somewhat soft and plastic. There is consequently an irregular channel along the top of the mass (Fig. 22, *c*), which is filled with the same frothy matter that surrounds each egg, while the matter occupies all the space in the burrow not occupied by eggs. The whole plan is seen at once by a reference to the accompanying figure, which represents, enlarged, a side view of a mass within the burrow (*a*) and a bottom (*b*) and top view of the same, with the earth which adheres to it removed.

Each female of the Rocky Mountain locust lays on an average about three egg-masses; this is done at intervals of two weeks so that the egg-laying season extends through six to eight weeks.

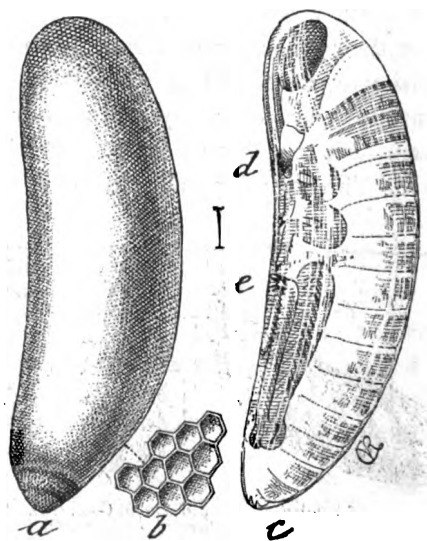


FIG. 23.—Egg of Rocky Mountain Locust—*a*, showing sculpture of outer shell; *b*, the same very highly magnified; *c*, the embryo, just before hatching. (Riley).

The egg is surrounded by a shell consisting of two layers, the outer one is thin, semi-opaque, thus producing a creamy yellow color; highly magnified it appears (Fig. 23, *b*) densely and minutely pitted or rather marked by hexagonal pits.

concavities (Fig. 23, *b*). The inner and thicker layer is deep yellow, smooth and translucent, so that the form of the embryo can be plainly seen when maturing inside. The outer layer is quite brittle, but the inner one very tough, requiring a strong pressure to rupture it. As the embryo within matures (Fig. 23, *c*), the egg-shell becomes weakened, and the egg plump and somewhat more transparent. By the muscular efforts of the enclosed insects, but chiefly by thorns arming the hind tibiae, (Fig. 23, *e*), the shell is eventually broken, and the young locust pushes its way through the neck of the burrow towards the light.

Nearly all the eggs in a pod hatch at the same time, and the young escape through the small hole left for this purpose. When the young insect reaches the surface it is quite weak, and still surrounded by a very delicate film, which has to be first removed before the young locust can jump about. By contracting and expanding muscular movements this enveloping film splits along the middle of the back, near the head, and is gradually pushed backwards, remaining as a white crumpled pellet behind. At first pale and colorless, the young locust assumes its dark color in the course of an hour.

From this account of the hatching process, we can readily understand why the female in ovipositing prefers compact or hard soil to that which is loose. The harder and less yielding the walls of the burrow, the easier will the young locust crowd its way out.

Though the covering which envelops the little animal when first it issues from the egg is quite delicate, it nevertheless, in the struggles of hatching, undoubtedly affords much protection, and it is an interesting fact that while, as we have seen, it is shed within a few minutes of the time when the animal reaches the free air, it is seldom shed, if, from one cause or another, there is a failure to escape from the soil, even though the young locust may be struggling for days to effect an escape.

While yet enveloped in this pellicle, the animal possesses great forcing and pushing power, and if the soil is not too compact, will frequently force a direct passage through the same to

the surface, as indicated by the dotted lines (Fig. 22, *e*), but if the soil is at all compressed it can make little or no headway even through the appropriate channel (Fig. 22, *d*). While crawling its way out, the antennæ and four front legs are held in much the same position as within the egg, the hind legs are generally stretched. But the members bend in every conceivable way, and where several insects are endeavoring to pass through any particular passage, the amount of squeezing and crowding they will endure is something remarkable. Yet by chance the protecting pellicle is worked off before issuing from the ground, the animal loses all power of further forcing its way out. The instinctive tendency to push upwards is also remarkable. In glass tubes, in which eggs were hatched in order to watch the young, these last would always turn their heads and push towards the bottom whenever the tubes were turned downwards; while in tin boxes, where the eggs were placed at different depths in the ground, the young never descended when they were unable to ascend on account of the compaction of the soil above.

The above minute account of the manner in which eggs are laid, and how the young are enabled to reach the surface, plainly indicates one good method by which the hatching of the young may either be prevented entirely, or by which the young may be prevented from reaching the surface. By plowing the fields containing eggs of the Rocky Mountain locust, we perform the following operations: first of all we remove the eggs from near the surface and cover them with five or six inches of soil; secondly, we invert the position of the hole containing the egg-mass, so that instead of its mouth pointing upwards, it now points downwards. At all events, the young insects are prevented from reaching the surface, if this becomes compacted by rain and snow. Consequently if we plow during autumn or soon after the eggs are laid we are safe; although if we plow in the spring with a notable amount of rain, we also effectually prevent their hatching. Plowing has this additional advantage: the egg-masses in many cases are thoroughly broken up, the individual eggs become

rounded by earth and moisture, and being no longer protected by the water-proof coat of dried mucous matter, they soon rot and perish.

The Lesser Migratory Locust lays its eggs in essentially the same manner. It always prefers, however, old stubble fields, bare spots in timothy fields, and neglected and dry pastures. In other words, well drained spots free of vegetation, and consequently soils free of roots, are preferred.

The Pellucid Locust has, in Minnesota, different habits as far as egg-laying is concerned. In the Western States it deposits eggs exactly like *spretus* and *atlanis*. The females of the Pellucid Locusts commence to deposit their eggs about the end of July, usually at least fourteen days later than the other migratory kinds. Their method of doing so is entirely different. As a general rule they select for this purpose pasture land, road sides, or, by preference, clearings from which the stumps have not yet been removed, although the land has already been used for crops. In such places large numbers of eggs are deposited in the sod. Usually they are placed right upon the surface of the soil, where they are protected by the grass and by the rubbish found in such situations (Fig. 24, *b* and *c*). Occasionally the eggs are deposited just beneath the surface, but only where the ground is sufficiently loose to enable the insects to do so. The eggs are about 4 mm. in length, and 1 mm. in diameter; they are slightly curved and rounded at the ends (Fig. 24, *a*). They are deposited in layers, each with three or four eggs, which overlap and appear somewhat irregular (Fig. 24, *b*). These diagonally overlapping layers are built up until an elongated cylindrical mass from 10 to 15 mm. in length is formed. This whole mass of eggs is protected by a water-proof covering composed of bits of earth cemented together with the frothy material produced by the mother insect at the time the eggs are deposited and arranged by her. One end of this protective layer of waterproof material is very thin, almost or entirely open, thus affording the young and weak locust an easy means of egress. Each cylindrical capsule contains about twenty eggs.

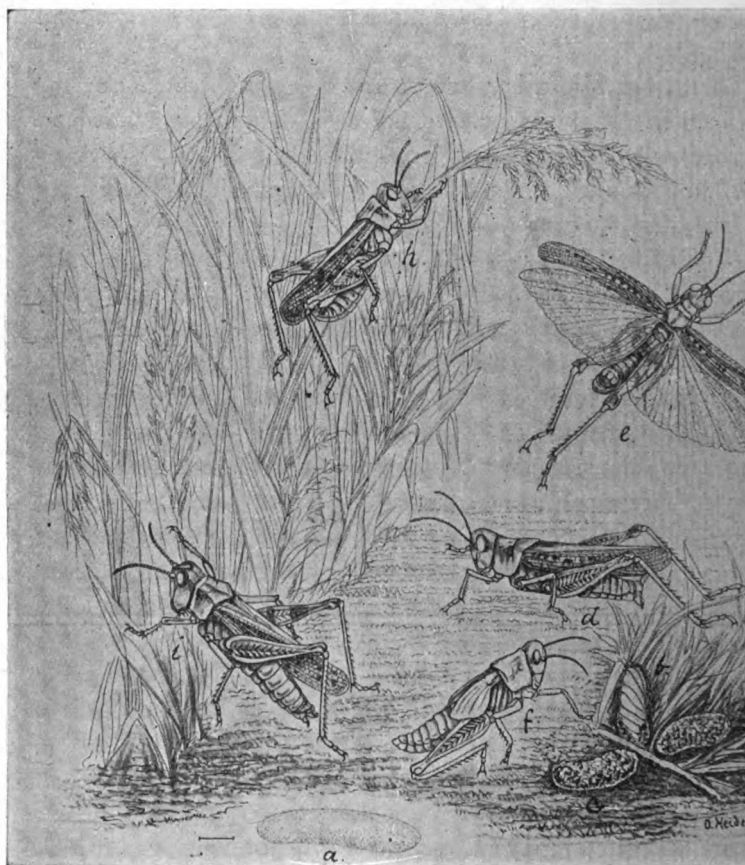


FIG. 24.—*a*, single egg of Pellucid Locust; *b*, egg-mass opened to show inside; *c*, egg-mass; *i*, female; *h*, male. Lesser Migratory Locust; *d*, female; *e*, *f*, pupa. Natural size. Original.

Fig. 24 shows the Pellucid Locust and its eggs; also Lesser Migratory Locust.

To distinguish with absolute certainty the three closely allied species *M. spretus*, *atlanis*, and the common native Red-legged locust (*M. femur-rubrum*) it is necessary to study the swollen abdomen of the males. Here we find constant differences

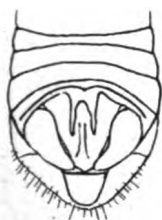


FIG. 27.

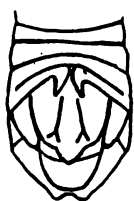


FIG. 26.

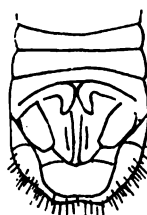


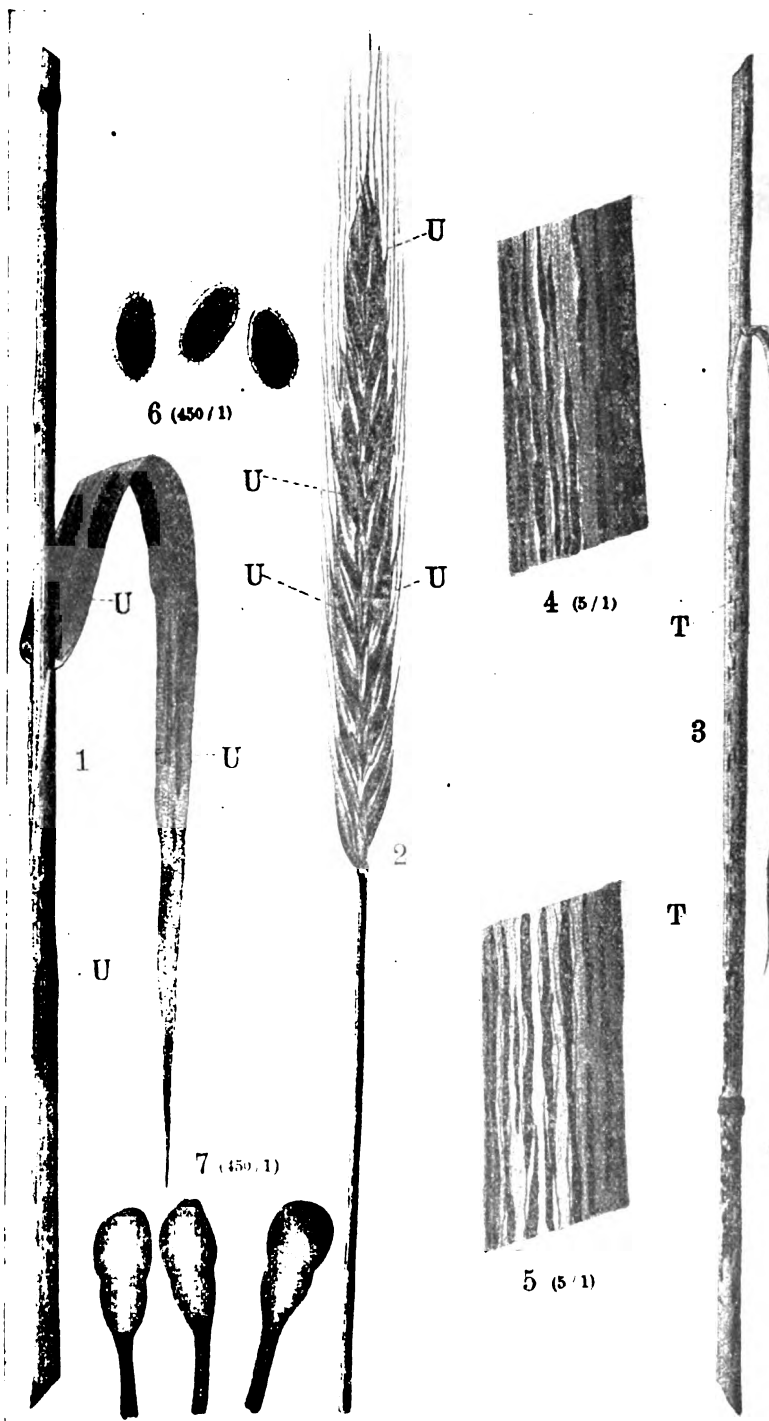
FIG. 25.

readily expressed in words. The illustrations show them very plainly. Fig. 25 illustrates the abdomen of *M. spretus*, Fig. 26, that of *M. atlantis*, and Fig. 27 that of *femur-rubrum*. It will be noticed that the two former ones have a decided notch at the tip. The females do not possess the peculiar knob-like ends of the abdomen, but have instead a pointed tip with four small and horny points used to drill a hole in the ground for the reception of eggs.

If we desire to get rid of the migratory species of locusts it is absolutely necessary to plow every inch of the cultivated ground, and especially the stubble-fields, which are invariably selected by the locusts for the purpose of egg-laying.

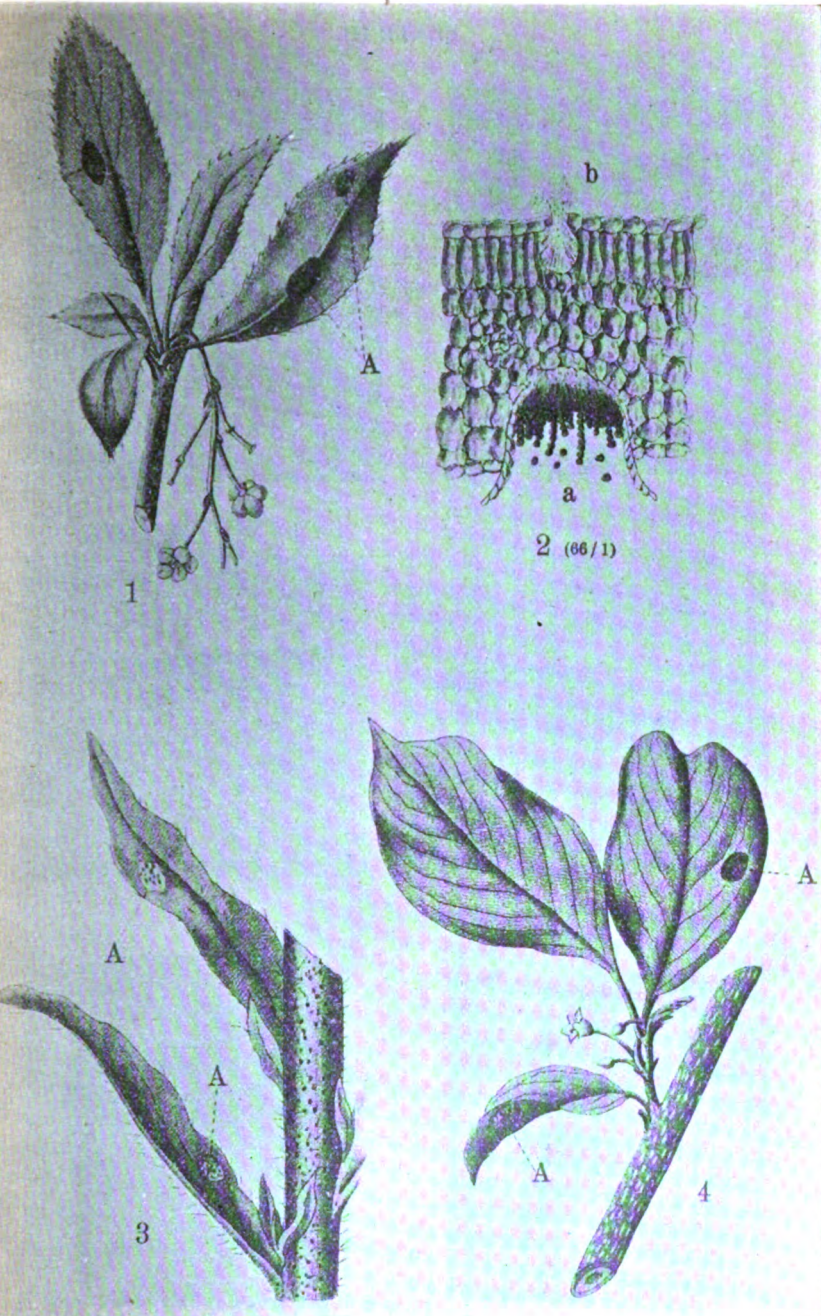
There are many other remedies that can be employed to kill these injurious insects, but not at the present time, and none are as effective as the one given.

Plate III and IV show the different kinds of locusts mentioned before.



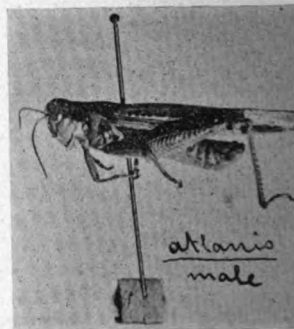
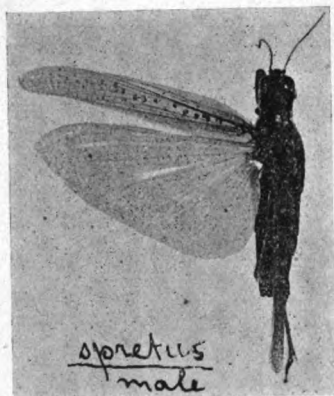
1. Rye plant, showing pustules (sori) containing red summer spores or uredospores (UU), natural size; 2, ear of rye with same, natural size; 3, pustules containing black winter spores or teleutospores (TT), natural size; 4, red uredospores enlarged five diameters; 5, black teleutospores enlarged five diameters; 6, three black winter spores enlarged 450 times; 7, three black teleutospores enlarged 450 times.

PLATE II.



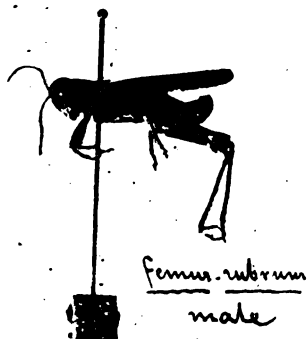
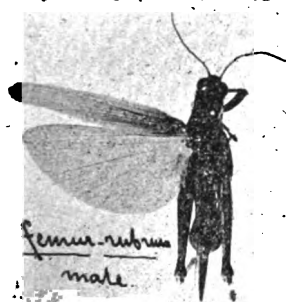
Æcidia, or Cups of Rusts. 1, AA of *Puccinia graminis*, Pers. (Black or Summer Rust), on leaves of barberry, natural size; 2, cross section through cup; a, cup with spores; b, spermogonium with spermatia, enlarged 66 diameters; 3, AA æcidia of *Puccinia rubigo vera*, Wtr. (Spring Rust), on Borage; 4, AA æcidia of *Puccinia coronata*, Cda. (Rust of Oats) on Buckthorn (*Rhamnus cathartica*); 3 and 4 natural size.

PLATE III.



Male and female Rocky Mountain Locust (*Melanoplus spretus*, W above, and male of same from the side. The Lesser Migratory Locust (*lanis*, Ril.) in same position. Enlarged about one-sixth.

PLATE IV.



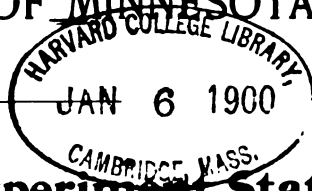
Male and female Common Red-Legged Locust (*Melanoplus femur-rubrum*, De Geer) from above, and male of same from the side. The Pellucid Locust (*Camula pellucida*, Scudder), male from side, female from above. The Common Two-Striped Locust (*Melanoplus bivittatus* Say.), female from above. Enlarged about one-sixth.

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Agricultural Experiment Station.

BULLETIN NO. 65.

CHEMICAL DIVISION.

NOVEMBER, 1899.

SOIL INVESTIGATIONS.

1. THE CHEMICAL COMPOSITION OF SOILS.
2. THE MECHANICAL COMPOSITION OF SOILS.
3. THE AVAILABLE PLANT FOOD OF SOILS.
4. CHARACTERISTIC FEATURES OF MINNESOTA SOILS AND CONSERVATION OF THE FERTILITY OF THE SOIL.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

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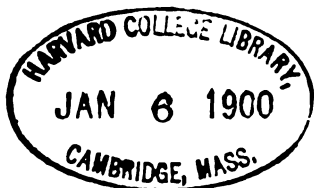
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From
The University

THE CHEMICAL COMPOSITION OF SOILS.

HARRY SNYDER.

The work reported in this bulletin is a continuation of the soil investigations reported in bulletins Nos. 30 and 41 of this station. Representative samples of soil from different parts of the state have been obtained and analyzed with the view of determining, as far as our present methods will allow, the amount of reserve plant food in our soils. The soil samples have been taken mainly by students of the College and School of Agriculture of the University of Minnesota. A complete record of the soil and of the crops produced was, in nearly all cases, secured, including the exact location of the fields sampled and the nature of the vegetation and the former productiveness of the soil. It is hoped that after a number of years of cropping, soil samples, from many of these same farms will again be taken and analyzed with the object of obtaining results as to the influence of different methods of farming upon the fertility of the soil. Samples of the soils analyzed have been preserved with the view of applying any improved method that may be devised for the determination of the available plant food.

Since many of the soils were secured from the farms of the students of the College and School of Agriculture, ample opportunity was afforded for a class room study of the results obtained. This has been of material value because it has given an opportunity for the chemist who made the analyses to meet and discuss the results with those who have cultivated the soils and are familiar with their productiveness and unique characteristics.

It is believed by many that the object of a soil analysis should be to determine the amount of available plant food, and during the last few years particular attention has been given to this phase of the work. Various dilute solvents have been tried for extracting

the available plant food but as yet the methods proposed have passed the experimental stage. In another part of this bulletin the subject of available plant food is discussed in detail.

In this work the use of hydrochloric acid as a solvent has been continued, and it is believed that a complete soil analysis with this solvent gives more information as to the general character of a soil than could be secured by the use of some weak solvent for the determination of only one or two constituents. While the complete chemical analysis of a soil requires considerable time and is expensive, it is believed that the results secured are of sufficient value to compensate fully for the time and labor involved. In this work it has been found that the best results are obtained when a number of soils of known fertility are analyzed and the results compared with soils of doubtful crop producing power from the same locality. A soil analysis when properly interpreted is not only capable of giving a general insight into the character of a soil but also of indicating whether the elements are present in what may be termed a balanced condition.

In many soils there are high percentage amounts of nitrogen, phosphoric acid, and potash, but good crops cannot be produced because of an unbalanced condition existing between the acid and basic constituents of the soil. Hence, in the interpretation of the results of a soil analysis the aim should be to consider the results in relation to each other rather than to consider each separately.

EXPLANATION OF TERMS USED.

Skeleton.—The term skeleton is used to designate the amount of coarse material in the soil. Particles of gravel and coarse sand which fail to pass through a sieve with holes .02 inch in diameter constitute the skeleton. The part which passes through the sieve is called fine earth. The amount of skeleton in soils will be found to range from 1 to 20 per cent. or more. In making a chemical analysis, only the fine earth is used, since the plant food in the coarse particles is in less accessible forms.

Humus.—This term is applied to the partially decayed animal and vegetable matter of the soil. Humus is composed of a large

number of organic compounds some of which are in chemical combination with the mineral matter of the soil forming the humate compounds. The value of humus has been discussed in former bulletins of this station (Nos. 41 and 53). Briefly stated, humus influences the physical properties of the soil, as power to absorb water and resist drought, and the chemical properties by rendering the inert plant food more active and available. The humus does not include all of the organic compounds of the soil, and the humus from two soils may be extremely unlike in composition and agricultural value because of the differences in the sources of the materials from which the humus was formed.

Nitrogen.—The total nitrogen given in the tables of analyses is present largely in organic forms. Nitrogen is one of the elements of which humus is composed. The value of nitrogen in plant nutrition has been extensively discussed in experiment station publications. When combined with the humus, the nitrogen must be broken down into simpler compounds before it becomes available as plant food. When the humus is broken down and nitrates and ammonium compounds formed, the nitrogen cannot be retained in the soil because both of these compounds are lost by drainage while the ammonia may also be lost by volatilization. Nitrogen is one of the chief elements of fertility. It is the most expensive element of plant food, and when the land is given a one crop treatment, as all wheat farming, the nitrogen is gradually reduced below the point necessary for good crop production. Causes for the decrease of nitrogen as excessive grain farming, summer fallowing, and burning over of stubble land have been discussed in previous bulletins to which the reader is referred for further information upon the subject. The decline in fertility of our prairie soils has been due more to the loss of nitrogen and humus than to any other cause.

Insoluble Matter.—The insoluble matter of a soil is the residue that is left after the soil is treated with hydrochloric acid of 23 per cent. strength for thirty-six hours, and is composed of sand and insoluble silicates. The insoluble residue cannot contribute to plant growth, as the elements are in such stable forms that they

are unavailable for crop purposes. Soils in general are composed of from 75 to 80 per cent. or more of insoluble matter. It can thus be seen that even in our most fertile soils over three quarters of the material with which plant roots come in contact is insoluble matter which cannot contribute to growth. In sandy and heavy clay soils the insoluble matter may amount to 88 per cent. of the total soil. The insoluble matter cannot be taken as an index of soil fertility or lack of fertility because what is dissolved in the soil water is not necessarily all plant food.

Potash.—The potash given in the tables of analyses is the soluble in the hydrochloric acid used for extracting the soil. It is not in the same form as the commercial potash used for fertilizer making, but is the potassium oxid that is combined with the silicic constituents of the soil. The element potassium is combined mainly with the elements oxygen and silicon forming silicates which are frequently found combined with various bases in the form of double silicates. The amount and form of the potash in the pounds of the soil have a great influence upon crop growth. The tables give the amounts of the potash, but unfortunately the potash is not all equally valuable as plant food. In a properly balanced soil, the potash is not so liable to be unavailable as some of the other elements. In the interpretation of results the potash and lime should be considered jointly, as explained on page 9.

Soda.—Since sodium takes, at the most, only a minor part in plant nutrition it would not be necessary to consider this element if it were not for the fact that in some soils an excess in the form of carbonate, sulphate, or chlorid may be injurious to vegetation. The sodium compounds of the soil may, however, when present in small amounts be of value, furnishing the necessary basic material for nitrification.

Lime.—The figures given for lime represent the amount of calcium oxide dissolved by the hydrochloric acid. The lime is not necessarily in the form of carbonate or limestone but frequently is in the form of silicate. If a soil contains .5 per cent. of lime and from .2 to .3 per cent. or more of combined carbonic anhydride

the lime is present mainly as lime carbonate. When considering the lime the reader should also note the per cent. of carbonic anhydrid. In many cases the high per cent. of carbonic anhydrid shows that the lime is in the form of carbonate. It is very desirable for a soil to contain a good stock of either lime carbonate or sulphate, which are active forms of basic material, and are also forms not injurious to vegetation. The active lime compounds of the soil take an important part both directly and indirectly in imparting fertility in the following ways: (1) By aiding nitrification or rendering the soil nitrogen available; (2) by preventing the soil from becoming acid; (3) by enabling the potash and other elements to be assimilated by crops; and (4) by improving the physical condition of soils.

Magnesia.—The amount of magnesia that a soil contains deserves consideration because the magnesium compounds are capable of influencing nitrification and acting upon the soil in a similar way to the corresponding lime compounds. Some of the soils of the Red River Valley, which rank among the most productive grain soils of the world, contain from 1 to 3 per cent. of magnesium carbonate. While magnesium takes an important part in plant nutrition it is not considered necessary to add this material to fertilizers because most soils contain a sufficient amount for crop purposes.

Iron and Alumina.—In the tables of analyses it will be observed that the amounts of iron, (as ferric oxid) and alumina, exceed the amounts of nearly all of the other constituents of the soil. The acid soluble part of soils is composed largely of alumina and iron compounds, originally present as acid soluble silicates. Alumina takes no part in plant nutrition. The amount of iron removed by crops is relatively small compared with the nitrogen or potash. Neither the iron nor the alumina compounds are of themselves particularly important ingredients of a soil but a large part of the plant food is frequently combined with them as the phosphoric acid, which forms insoluble phosphates of iron and alumina; these are unavailable as plant food.

Phosphoric Acid.—The figures given in the tables for phospho-

ric acid or anhydrid are for the phosphorus pentoxid content of soil. The form in which the phosphates are present has a great influence upon fertility. In prairie soil a part of the phosphoric acid is in chemical combination with the humus. In many soils phosphoric acid is combined with the iron and alumina. If the soil contains a sufficient amount of humus and available or other active alkaline matter, the phosphoric acid combined with the humus is available as plant food. If the soil is in an acid condition the phosphates combined with the humus are unavailable. A good content of phosphoric acid is very desirable, particularly when associated with the humus and alkaline matter.

Carbonic Anhydrid.—The carbonic anhydrid or carbonic gas which a soil contains depends upon the amounts of lime and magnesium carbonates present. A liberal amount of carbon dioxide from carbonates in a soil is desirable, provided there is not an excess of either potash or soda. As stated in the paragraph relating to lime the amount of carbon dioxide in case the soil is excessively rich in organic matter can be taken as an index of the form of the lime.

Volatile Matter.—By the term volatile matter, as used in soil analysis, is meant that part of the soil that can be volatilized at a high temperature. The volatile matter is composed largely of organic matter, water held in chemical combination by the hydrated silicates, and small amounts of combined carbon dioxide. In many cases the volatile matter has been confused with the vegetable matter. Clay subsoils containing but little vegetable or organic matter, may contain from 5 to 7 per cent. of volatile matter in the form of water held by the hydrated silicates. The volatile matter tells only in an indefinite and general way the amount of vegetable matter contained in a soil. Soils of high fertility contain from 10 to 12 per cent. or more of volatile matter. In some peaty soils the amount may exceed 50 per cent. A high per cent. of volatile matter is not always an index of fertility.

INTERPRETATION OF RESULTS.

Infallible rules for the interpretation of the results of

analysis, applicable to all classes of soil, cannot be formulated. It is of more importance to consider the general make-up or character of a soil than that a soil should contain a certain specified amount of each plant food element.

From the work reported in this and in former bulletins it has been found that many soils of high fertility possess certain important characteristics which are capable of being revealed by a chemical analysis. It is not intended to convey the idea that a chemical analysis is alike capable of determining the productiveness of all classes of soils. The chemical analyses reported in this bulletin have been supplemented by numerous mechanical analyses, and in addition to the usual determinations using hydrochloric acid as a solvent, other determinations have been made; as the humus by the modified Grandeau method, phosphoric acid content of the humus, total nitrogen, lime in the form of carbonate soluble in carbonated water as proposed by Hallemann, and the reaction of the soil. In discussing the individual soils all of the results by these various determinations have been used. For the sake of brevity, however, the tabulated results are given only in one place, but the reader can from the soil numbers identify the individual soils given in the various tables.

Many of the soils examined, particularly the subsoils, have shown a general composition like soil No. 2, while a few have shown a general composition like No. 1. Soils like No. 2 have invariably been of high fertility, while some of the soils similar to No. 1 have also produced good crops. The composition of the two types of soil is given in the following table:

TABLE I.—Soil Types.

	SOIL 1 Per cent.	SOIL 2 Per cent.
Total insoluble matter.....	82.40	80.25
Potash.....	.45	.40
Soda.....	.35	.30
Lime.....	.45	.45
Magnesia.....	.22	.20
Iron and alumina.....	6.27	6.12
Phosphoric anhydrid.....	.18	.15
Carbonic anhydrid.....	.01	.20
Sulphuric anhydrid.....	.01	.03
Total nitrogen.....	.22	.18
Humus.....	2.60	1.88

From the table it will be seen that soil No. 1 contains more

nitrogen, phosphoric acid and potash than soil No. 2; but soil No. 2 annually produces larger crops than soil No. 1. How are these facts to be harmonized? If judged by the standard of high percentage amounts, soil No. 1 should be the more productive but soil No. 2 is the more productive.

In soil No. 1 a low per cent. of carbonic and sulphuric anhydride is found. In this soil the lime and magnesia are not present in either carbonate or sulphate. The soil is deficient in active lime material and as a result nitrification is slow and there is a lack of available nitrogen. Soil No. 1 contains a relatively high per cent. of humus, a valuable material, but the absence of active lime material in this soil results in the formation of humic acid and the soil becomes sour. There is a high per cent. of potash but because of the absence of available lime or other alkaline matter the potash cannot become available. Neither can the phosphoric acid become available while the soil is in its present condition but in the presence of sufficient alkaline matter the phosphoric acid combines with the organic matter and becomes available. While soil No. 1 contains a high percentage amount of nitrogen, phosphoric acid, and potash, the soil is not one of high productiveness because of the unbalanced condition of the acid and basic constituents. On the other hand, a soil may be unbalanced by containing an excessive amount of alkaline matter as in the case of "alkaline" soils.

Soil No. 2 contains less nitrogen, phosphoric acid and potash than No. 1 but a better balanced condition of the elements exists. The higher percentage amounts of carbonic and sulphuric anhydrides indicate that the lime and magnesia are present mainly in the forms of carbonates and sulphates. The more active forms of the alkaline compounds in this soil (No. 2) promote nitrification, enable the potash to become available, and as a result better crops are produced. Consequently in this soil there is a better balanced condition of the plant food than in No. 1, which contains a higher percentage amount of plant food. Hence it will be seen that in the case of soils of high fertility a liberal amount of plant food exists in neither an excessively acid nor alkaline condition.

and that chemical analysis is frequently of value in determining whether the elements are present in a soil in a balanced condition.

Soils of high fertility are occasionally met with that do not possess all of the features of soil No. 2, while some soils like No. 1 have produced good crops. No soil of this state has as yet been analyzed that possessed all of the characteristics of soil No. 2 and was deficient in available plant food. In examining the tables the following tentative standards may be applied. They have been used in class room work at the School of Agriculture, University of Minnesota, for the interpretation of the results reported in this bulletin and have been found to give reasonably correct interpretations of the analytical results. As to what extent they can be applied to soils of widely different character, and from other localities cannot be stated, but they have given good results under the conditions to which they have been subjected.

Lime.—Soils which contain from .3 to .5 per cent. or more of lime and from .1 to .4 per cent. of combined carbon dioxide, and are not strongly charged with alkaline salts, are reasonably well supplied with active lime compounds. If, however, the soil contains only from .01 to .02 per cent. of carbon dioxide and a similar amount of sulphur dioxide then the lime is probably present as a silicate, in which case the soil may stand in need of a lime fertilizer. Some soils have been observed which yield only .01 per cent. or so of carbon dioxide but contain .10 per cent. or more of sulphur dioxide; in such cases the lime is present as sulphate, an equally active form. Many surface soils appear to be deficient in lime, while the subsoils are well supplied. A low per cent. as .01 of carbon and sulphur dioxides in both the surface and subsoil is generally an indication that the lime is not in an active form. A large amount of organic matter in the surface soil may result in the liberation of sufficient carbon dioxide to cause trouble in the interpretation of results; hence, it is more desirable to consider the subsoil percentage, as the subsoils contain, as a rule, but little organic matter.

Nitrogen.—Prairie soils of average fertility show high percentages of nitrogen. Virgin soil from the Red River Valley has been found with .6 per cent. of nitrogen. Soils of average fertility

contain from .15 to .20 per cent. With less than .07 per cent there is usually a decided deficiency. The availability of nitrogen depends largely upon the condition of the soil. If there is a good supply of available lime or other basic matter the conditions are favorable for nitrification, and a smaller percentage amount of nitrogen will suffice for crop growth. Warington states that not more than 2 per cent. of the total nitrogen of soil is available as plant food at any one time. Three-tenths per cent. of nitrogen is equivalent to about 10,000 pounds per acre to the depth of one foot. If 1 per cent. were available there would be only 100 pounds of available nitrogen, of which but a small part comes in contact with the roots of crops. Thus it will be seen that while a soil may contain a large amount of total nitrogen it may still be deficient in available nitrogen. Average soils contain .15 per cent. of nitrogen, and with a good stock of available lime are not apt to be deficient in available nitrogen. The appearance of the foliage of a crop is a safe guide as to the availability of the nitrogen. With a good supply of available nitrogen the leaves of plants are large and of a deep green color. Small leaves of a yellowish tinge are an indication of an unavailable form of nitrogen.

Potash.—Fertile soils usually contain from .3 to .6 per cent. of potash. The availability of the potash depends upon the general character of the soil. With a good supply of available lime and magnesia the potash of the soil is usually in an available form. A soil may contain .50 per cent. of acid soluble potash, but in the absence of lime or other basic material the crops may suffer for the want of potash. In considering the availability of potash the lime and magnesia should be considered jointly with the potash. Soils that contain .4 per cent. of potash and .4 per cent. or more of lime as carbonate or sulphate are as a rule well supplied with available potash.

Phosphoric Acid.—Hilgard states that if the soil contains less than .05 per cent. of phosphoric acid there is in all probability a poverty of this element. "A soil that gives an alkaline or neutral reaction and contains .15 per cent. of phosphorus pentoxid, and

well supplied with organic matter and lime, is amply provided with phosphoric acid, and under such conditions the extensive use of phosphate fertilizers is not required except possibly for special crops." (Chemistry of Soils and Fertilizers.) In considering the availability of the phosphoric acid, the following facts should be observed: Is there (1) a reasonable amount of total phosphoric acid (at least .12 per cent.); (2) a good working supply of humus, so that humic phosphates may be produced; and (3) a good supply of available lime or other alkaline matter to prevent an acid condition of the soil?

As the reader examines the tables he will observe that there are frequently large areas of the state that are not represented. In former bulletins reports are given of soils from many of the localities that are not included in this report. In all about three hundred and fifty samples of soil have been analyzed and in this bulletin the analyses of one hundred and twenty-six surface and subsoils are given. Because of the extreme variation in the composition of the soils from different parts of the state, no attempt has yet been made to make soil maps. This can be done more intelligently after a larger number of soils have been collected and analyzed. In this report the soils have been grouped geographically. The soils from the southeastern part of Minnesota are given first, then those from the southwestern part followed by those from the northwestern and finally those from the northeast. Analyses have been made of both the surface and subsoils and in the discussion of results they are jointly considered.

DISCUSSION OF RESULTS.

Soil No. 563 (subsoil 564) from Castle Rock, Dakota County, has been under cultivation for about thirty-five years. Wheat and small grains have been the main crops produced, some clover and timothy have been grown, and during the past fifteen years liberal use has been made of farm manure. Both the surface soil and the subsoil contain a good supply of lime. The carbonic and sulphuric anhydride percentages indicate that a large part

of the lime is in the active forms of carbonate and sulphate. potash is high, and a good supply is present and available because of the active form of the lime. The soil is well stocked with phosphoric acid, which is available because the soil contains a good supply of humus and active lime and potash. In the presence of basic material the humus and phosphoric acid combine and form available plant food. The fact that grains have not been grown exclusively and that manure has been used, and some clover and hay crops grown, is shown by the nitrogen and humus content of the soil. In this soil and in the soil the acid and basic constituents are well balanced, and the soil is one of high fertility.

Soil No. 557 (subsoil 558) is from the same locality as soil No. 563 and has the same general composition. The land was originally open prairie. The farmer who took the sample reports that the soil was all very much alike in texture and crop producing power. The sample is a composite one from a large farm which has been cultivated about thirty-five years to wheat, oats, flax, and grass crops. During the past ten years farm manure has been liberally used. The manure has been applied directly to the pasture. Soiling crops have been raised and fed, thus reducing the pasture land to one-third of the former acreage. The soil is so similar in composition to No. 563 that the statements made by the farmer regarding the plant food and its availability apply equally well to this soil. The high per cent. of plant food and the balanced condition of the elements, together with the intelligent system of farming followed, have resulted in maintaining the original productiveness of this soil.

Soil No. 535 (subsoil 536) is also from Dakota County. The surface soil contains less insoluble matter than is found in the samples previously reported from this county. The high per cent. of soluble alumina is particularly noticeable. The soil is one of high fertility and is well stocked with plant food in available forms. The soil has been cultivated thirty years in about the same way as soils Nos. 557 and 563.

Soil No. 513 (subsoil 514) from Lakeville, Dakota County

rich in plant food, particularly in nitrogen. In these soils there is a liberal amount of lime, but there is less in the active form of carbonate and sulphate than in the preceding soils from this county. This soil, however, contains a good working supply of available alkaline matter, and is in a good state of productiveness. The subsoil, although not deficient in lime, gives a faint acid reaction, while the surface soil is neutral.

None of the soils from this part of the state have been found to fall below the provisional standards given, and a well balanced condition has been found to exist between the acid and basic constituents of the soils examined. Some of the soils previously analyzed have shown low percentages of nitrogen and humus due to excessive cropping to small grains. This has resulted, as pointed out in previous bulletins, in decreased yields.

Soil No. 527 (subsoil 528) is from Kenyon, Goodhue County. The soil was originally sparsely covered with oak, ash, and cottonwood. But little manure has been used, the land, however, has been pastured and has produced some hay. There is more lime in the form of carbonate (limestone) in the subsoil than in the surface soil. In this surface and subsoil, magnesia is more liberally present than is lime. The subsoil gives a slightly acid reaction. The soil has produced good crops of small grain, particularly oats. Both the surface and subsoil are rich in humus and nitrogen. In general the soil conforms to type No. 2, but the surface soil is not too liberally supplied with lime carbonate. This apparent deficiency is corrected by the higher content in the subsoil and also by the fact that the lime is in part in the form of sulphate.

Soil No. 616 (subsoil 617) has been cultivated thirty-five years to small grains and corn. The land has been manured only once, and the fields begin to show signs of "wearing out." The lime, magnesia and carbonic and sulphuric anhydrides show that there is a good balance of basic matter in the soil, and there is also a liberal amount of potash and phosphoric acid. The nitrogen and humus percentages are, however, low, and the "wearing out" is due to the excessive drain on these constituents caused by all-

grain farming. Clover, manure and rotation of crops w this soil in a good state of productiveness. There is a fair ing supply of available mineral food, but the lack of a nitrogen is severely felt. Many soils of a similar character be improved by the course of treatment here proposed.

Soils Nos. 521 (subsoil 522) and 553 (subsoil 554) are different farms at Holden, Goodhue County, and have the general composition. Both have been cultivated for about years to wheat, oats, barley and corn. Moderate amounts nure have been used, and some clover and timothy have produced on soil No. 521. The soils are well supplied with and lime; a part of the lime is in the form of carbonate phosphoric acid percentages are somewhat lower than those in many soils, but from the crops produced there is no ev of want of available phosphoric acid. The humus content surface soils is high. In the case of soil No. 553 a separate mination showed that 75 per cent. of the total phosphor was extracted along with the humus. It is probably the forms of phosphoric acid which supply the crops with a phosphates. The available lime and other basic materials soil have a tendency to render the humic phosphates avail

Soil No. 555 (subsoil 556) from Zumbrota, Goodhue C has been cultivated forty years; the land was originally c with oak. Wheat has been one of the main crops grown, land has been manured only twice during its cultivation. hay has been raised and the land has been pastured. The characterized by a good content of lime and magnesia in forms, and liberal amounts of potash and phosphoric acid nature of cropping to which this soil has been subjected l resulted in conserving the nitrogen and humus, both of have been reduced below the amounts found in the best s this locality. If given the same treatment as recommen soil No. 616 larger crops would be secured.

Soil No. 577 (subsoil 578) Red Wing, Goodhue Coun been cropped to wheat, corn, oats, barley, and grass for thi years. Manure has been sparingly used and good crops ha

duced. The subsoil is rich in lime, which is present both as carbonate and sulphate. The potash and phosphoric acid are present in reasonable amounts, and in available forms because of the balanced character of the soil constituents. There still remains a good supply of nitrogen which readily becomes available because of the presence of sufficient basic matter.

Soils Nos. 572 and 573 (subsoil 574) from Stanton, Goodhue County, are all well stocked with plant food. The soils are well supplied with lime in the form of carbonate. Soil No. 572 has received better treatment in the way of manuring and cropping than soil No. 573. The soils have shown themselves to be particularly adapted to corn culture and they have also produced good crops of sugar beets. The nitrogen percentages are high, and the deep green color of all the vegetation indicates that there is an abundance of nitrogen in available forms.

Soil No. 515 (subsoil 516) from Hammond, Wabasha County, has been cultivated about forty years. At first small grains were raised but during more recent years mixed farming has been followed. The soil although underlaid with limestone does not contain as much active basic material as do many soils from the same locality. Both the surface and the subsoil give slightly acid reactions. Good crops have been produced and the soil shows a good content of total nitrogen and phosphoric acid.

Soil No. 503 (subsoil 504) has the same general composition and characteristics as soils Nos. 515 and 516. The soil (503) was originally covered with oak and mixed timber, and has been cultivated about twenty-five years, wheat, oats, barley, corn and grass being produced. The active basic matter is not as high as in the other soils. Both the surface and subsoil, however, contain an unusually high per cent. of phosphoric acid.

Soil No. 618 (subsoil 619) from Kellogg, Wabasha County, has been cultivated thirty-five years. The land was originally covered with "scrub" oak. Fair crops have been produced, corn and oats giving the best yields. Both the surface and subsoil give slightly acid reactions. From the analysis it would appear that the lime is in the form of sulphate rather than carbonate. There

is a good store of nitrogen and phosphoric acid, and a reasonable amount of potash. If the soil contained more active basic matter the plant food would be in more available forms, and more crops could be produced. The use of wood ashes upon the soil would be beneficial for certain crops as it would increase the supply of basic matter.

Soils Nos. 596, 597, and 598 were taken from different fields at Stockton, Minn. These soils were from sugar beet fields where it was desired to learn why there was such a difference in the sugar content of the beets from the different fields. Under nearly similar conditions soil No. 598 produced beets with 13 per cent. sugar, while soil No. 597 yielded beets with 13 per cent. sugar, and the beets on soil No. 596 showed only 12 per cent. sugar. The chemical analyses of the three soils show that soil No. 598 is characteristically rich in limestone, while in soils Nos. 596 and 597 there is only a minimum amount of active lime. There is only a slight variation in the potash content of the three soils. Soil No. 597 contains more nitrogen and phosphoric acid than No. 596. The soil (598) which produced beets with the highest content of sugar contained the most lime as a fertilizer. It is evident that for the culture of sugar beets a careful selection should be made of the soil upon which the beets are to be grown. Sugar beets thrive best on loam soils well stocked with lime. There are large areas of such soils in this state. Soil No. 598 is what may be termed a well balanced soil, capable of producing a variety of crops because of the available form of plant food.

Soil No. 567 (subsoil 568) from Moscow, Freeborn Co. was originally covered with oak and has been cultivated for five years; wheat, oats, barley and corn being grown in rotation. Manure was applied to each corn crop. The soil is in a fertile condition and is well supplied with available plant food. A separate determination of humic phosphoric acid showed that about 80 per cent. of the total is associated with the humus.

Soil No. 594 from Albert Lea was taken from a field that produced sugar beets with a high content of sugar. The soil is

acteristically rich in nitrogen and phosphoric acid and contains the acid and basic constituents in a well balanced condition. The soil was originally timbered with oak and has produced good crops of small grains and grass. Soil No. 592 is from the same locality and has been heavily manured. The difference in the content of humus and of volatile matter of the two soils is particularly noticeable. But few soils have been examined which contain such a high per cent. of vegetable matter in humic forms as No. 592. The soil gave a neutral reaction, but the subsoil showed a slightly acid reaction. The soil is unusually well supplied with plant food. Beets produced upon this soil gave a large yield per acre and tested 14.1 per cent. sugar. The liberal amount of plant food resulted in the production of a beet crop of large yield per acre rather than one of high sugar content.

The soils from Oakland, Freeborn County, were taken from places from a half mile to two and a half miles apart. Soil No. 581 was from a cultivated field. The nitrogen determinations were repeated by different analysts because such an unusually high percentage was found. Cultivated fields are rarely found with as much nitrogen. The soil belongs to the lime type and is well supplied with plant food. Soil No. 584 exhibits the same general characteristics as No. 581. The sample was taken from a sugar beet field. This soil is unusually rich in lime and magnesium carbonates.

Soil No. 519 has raised three crops since it was cleared of the oak timber and brought under cultivation. It is well supplied with lime carbonate and potash and the indications from the chemical analysis are that the soil is well supplied with plant food. While there is less total phosphoric acid than is contained in many soils the per cent. is not so low as to cause any concern about this element.

Soil No. 533 (subsoil 534) from Waltham, Mower County, has been cropped for eighteen years to flax, wheat, oats and barley. Of late years the land has been in pasture and meadow. No manure has ever been used. Considering the nature of cropping and the fact that no manures have been used the nitrogen and

humus percentages are exceptionally high. The soil contains a amount of active alkaline matter but is not overstocked. subsoil gives a slightly acid reaction. Good crops have been produced; the soil appears to be specially adapted to the growth of barley, oats and timothy.

Soil No. 626 (subsoil 627) from Brownsdale, Mower County, originally an open prairie soil, has been cultivated forty years with wheat, oats, barley, corn and flax. Manure has been used every six years and good crops have always been produced. The soil is well supplied with humus and nitrogen. The surface gives a slightly acid reaction and the analysis indicates that there is not a large amount of lime carbonate or sulphate present. From the nature of the crops produced there is no evidence of lack of available plant food. The frequent manuring of the crop is what has kept this soil in its high state of productivity.

Soil No. 633 from Kedron, Fillmore County, was taken from a low place. There is nearly 6 per cent. of calcium carbonate in this soil. The amount of volatile matter is exceedingly high due to the large amount of vegetable matter present. The soil gives a neutral reaction. There is a large amount of plant food and the soil is in a well balanced condition as far as acid and alkali constituents are concerned.

Soil No. 505 (subsoil 506) from Alma City, Waseca County, contains an unusually high per cent. of phosphoric acid. The potash and lime carbonate content is not as large as could be desired, and the soil appears to be a little weak in active lime material. Both the surface and subsoil give slightly acid reactions. The soil has produced good crops, but any decline in yield should be followed by the use of some alkaline fertilizer as wood ashes or lime. The soil is slightly different in character from the prevailing type of this locality.

Soil No. 561 from Fairmont, Martin County, contains in both the surface and the subsoil a good supply of carbonate of lime. The soil gives a neutral reaction. This land has been cultivated six years to flax, wheat, oats and corn. There is a higher per cent. of potash, and a lower per cent. of phosphoric acid than usually found in similar prairie soils. The phosphoric acid

however, associated with the humus, as shown by separate determinations. There is a good balance of plant food in this soil.

Soil No. 531 (subsoil 532) from St. James, Watonwan County, is a prairie soil that has produced ten crops of flax, wheat, oats, corn and barley. One application of manure has been made to the corn crop. The soil is well supplied with plant food, which is in a balanced condition. Both the surface and subsoil give a neutral reaction, and are liberally supplied with lime carbonate. The potash content is high, and the presence of the lime carbonate would indicate that the potash is in forms available for crop growth. The soil has retained its nitrogen unusually well, considering it has had ten years' grain cultivation.

Soils Nos. 606, 607, and 608 from Madelia, Watonwan County, are from different fields of the same farm. The soils were originally open prairie, and since they have been cultivated have shown decidedly different crop producing powers. "Soil No. 606 has produced fair crops, No. 607 good crops, while No. 608 has sometimes produced poor crops, and sometimes very good crops." The soil which produces the good crops (607) contains the same amount of phosphoric acid and less potash than the soil which produces the poor crops (606). In the soil which produces the good crops there is, however, twice as much lime and magnesia, and a larger amount of humus and nitrogen than in the poorer soil. Soil No. 606 is deficient in available nitrogen, because there is not a large total amount and there is not sufficient basic matter in the soil to render this nitrogen available. The soil (608) which sometimes produces poor crops and sometimes very good crops contains more total plant food than the soil that always produces good crops. Soil No. 608 contains a liberal amount of lime carbonate and basic matter, and is well supplied with nitrogen, phosphoric acid, and potash. The unevenness of its productiveness would appear to be due to some physical condition, as poor drainage, which in turn influences the availability of the plant food by preventing nitrification. It would be an advantage to grow some strong feeding crop, as oats, for three or four years on soil No. 608 so as gradually to get the land into better physical condition

for future crops. Many heavy prairie soils which are well stocked with lime carbonate sometimes require cropping with strong and indifferent feeding crops, as oats, before the necessary reaction between the large amount of organic matter and lime can take place. Prairie soils like No. 608 invariably improve with cultivation.

Soil No. 523 (subsoil 524) from Norseland, Nicollet County has been cultivated only a few years. The soil contains a high per cent. of both nitrogen and humus and gives a neutral reaction. The carbonic anhydride content indicates that a liberal amount of the lime is in the form of carbonate. As far as plant food is concerned the soil is well supplied, and the plant food appears to be in a balanced form.

Soil No. 559 (subsoil 560) was taken from four fields near Winthrop, Minn. The land had been cultivated twenty-five years with wheat, barley, oats, corn and flax and had received one application of manure. The soil is characteristically rich in limestone, and gives a neutral reaction. While the nitrogen and humus percentages are very high, they are less than found in similar soils that have not been brought under cultivation. Similar soils from the same locality have produced sugar beet crops testing 18 per cent. sugar and yielding twenty tons per acre. The high content of lime and the balanced condition of the plant food account for the adaptability of this soil to beet culture.

Soil No. 511 (subsoil 512) from Sacred Heart, Renville County is a prairie soil that has been cultivated twenty years to wheat, oats, and corn, manure being used on the corn crops. The surface and subsoil both give a neutral reaction. The soil is well supplied with carbonate of lime and the plant food is present in liberal amounts and in available forms. The analysis indicates that the acid and basic constituents are present in a balanced condition. The soil has invariably produced good crops.

Soil No. 599 (subsoil 600) from Lynd, Lyon County, is from an experimental plot on the farm of Supt. O. C. Gregg. The soil sample was taken at a depth of three to four feet from the surface. The large amounts of limestone, and potash and alkali

matter in the subsoil are characteristic features. The soil contains a very good working supply of nitrogen and humus, and the plant food is apparently in a balanced condition.

Soil No. 502 from Dawson, Lac qui Parle County, is characteristically rich in humus, nitrogen, potash, lime and phosphoric acid. The plant food is in a well balanced condition because of the active forms of the lime and alkaline salts.

Soil No. 568a from Marietta, Lacqui Parle County, is not a characteristic soil of that fertile locality, but is one representing only a limited area. The analysis shows a very high per cent. of sulphuric anhydrid, present in the form of lime sulphate or gypsum. There is also an abnormal amount of sulphate of soda. The influence which such a large amount of gypsum would have upon crop growth is difficult to tell. Good drainage and thorough cultivation so as to open up the land and allow the alkali to drain away would be the best treatment that this soil could receive.

Soil No. 624 (subsoil 625) from Willmar, Kandiyohi County, is unusually well supplied with humus, nitrogen, phosphoric acid and potash. The subsoil contains over 22 per cent. of lime and magnesium carbonates. The soil has produced good crops of wheat, oats and small grains. Timothy has also been grown. There is a high per cent. of plant food in available forms because the soil has such a well balanced composition and contains a liberal amount of active basic matter. With a good system of crop rotation soils like No. 624 will stand very heavy cropping.

Soil No. 537 (subsoil 538) from Bigstone, Bigstone County, has raised twenty crops since the original prairie sod was broken. The soil has produced good crops of wheat, flax, oats and millet. The soil is in a good state of productiveness, although the nitrogen has been considerably reduced below the original amount. There is a good supply of phosphoric acid and of lime in an active form. As long as the nitrogen is kept up there will probably be no decline in crop yields.

Soils Nos. 588 (subsoil 589) and 590 (subsoil 591) are from Pennock, Kandiyohi County. Soil No. 588 has been cultivated

twenty-seven years, while soil No. 590 has never been cultivated. The soils are somewhat dissimilar in general texture and position so that conclusions cannot be drawn as to the effect of cultivation. Soil No. 588 produced seventeen consecutive crops of wheat and four crops of oats and was then seeded down for meadow and pasture, and finally plowed up and seeded to flax. Both the surface and subsoil are well supplied with plant food in the form of carbonate. The soil contains a good stock of plant food in a well balanced condition. The uncultivated soil is materially richer in nitrogen and evidently contains a more abundant amount of plant food than was originally present in soil No. 588. Soil No. 588 gives a slightly acid reaction, while the subsoil is neutral. Soil No. 590 and the corresponding subsoil are alkaline. Subsoil No. 591 contains a high content of lime carbonate. While the phosphoric acid content of the subsoils is high, the surface soils contain a more liberal amount, a portion of which is combined with the humus.

Soil No. 620 (subsoil 621) from Lintonville, Kandiyohi County, contains a high per cent. of nitrogen and humus, as well as lime and phosphoric acid. The surface soil gives a neutral reaction and is well stocked with active alkaline matter. Although the subsoil contains .72 per cent. of lime the larger portion of it is in the form of silicate, and is inactive. The subsoil gives a slightly acid reaction. The soil has produced good crops and from all indications is well supplied with plant food.

Soil No. 609 from Benson, Swift County, has been suited to wheat culture for a number of years. While the nitrogen content is somewhat reduced, the soil still continues to produce satisfactory crops of wheat. There is a good working supply of lime carbonate in the soil, and also a liberal amount of phosphoric acid. The acid and basic constituents are well balanced. The physical and chemical composition would indicate that the soil is particularly well adapted to the production of grass and hay. The chemical analysis would indicate that a change in method of culture would be desirable so as to increase the stock of nitrogen and humus.

Soil No. 525 (subsoil 526) from Hegbert, Swift County, is a prairie soil that has produced only one crop of wheat. The soil is unusually rich in humus and nitrogen, and the subsoil contains over 25 per cent. of lime and magnesium carbonates. There is a high per cent. of alkaline matter in the subsoil. The composition would indicate that the soil is rich in plant food and that there is a good supply in available forms. Many soils like No. 525 contain so much plant food that when they are first brought under cultivation trouble arises from the excess of fertility producing a rank growth of straw and subsequent lodging of the crop.

Soil No. 551 (subsoil 552) is from Starbuck, Pope County. The land has been cultivated twenty years to wheat and corn, manure being applied every four years to the corn land. The soil shows a high percentage of nitrogen and humus. About 75 per cent. of the phosphoric acid is combined with the humus. Only a relatively small amount of the lime is in the form of carbonate; both the surface and subsoil give a neutral reaction. The physical and chemical analysis would indicate that the soil is better suited to the culture of barley or oats than to the exclusive growth of wheat, as has been practiced.

Soil No. 517 (subsoil 518) from Pelican Rapids, Otter Tail County, has produced eight crops of wheat since the oak and other timber were cleared from the land. The surface and subsoil are both well supplied with lime carbonate and potash compounds. There is a good store of plant food, including nitrogen and the soil is in a well balanced condition. It would be desirable to begin rotating the crops at this point in the cultivation rather than to continue exclusive wheat culture, as is frequently done until the nitrogen, humus, and available plant food are reduced below the point required for the production of good crops.

Soil No. 571 is from Becker County, Minn. The soil is well supplied with plant food, and while the amount of lime carbonate is low, there are no indications of lack of alkaline matter. The soil gives a neutral reaction. Many soils of this character, rich in nitrogen, humus, and other forms of vegetable matter cause

some trouble when first brought under cultivation due to lack of perfect drainage rather than to a fault in chemical composition. The nitrogen and humus have been preserved because of the presence of water, and when the land is first drained a few years of culture are sometimes necessary before the reserve fertility becomes available.

Soil No. 632 from Vining, Otter Tail County, contains a good working supply of plant food. While the percentage amounts of nitrogen and phosphoric acid are not large there is a reasonable amount which can be kept in available forms provided a good rotation is followed and farm manures are used. The elements are present in a well balanced condition, and in general the soil conforms to type No. 2, previously discussed.

Soils Nos. 612, 613 and 614 (subsoil 615) from Lockhart, Otter Tail County, represent different types of soil from the Red River Valley. The composition of the soils from this part of the valley is discussed in detail in former bulletins (Nos. 36 and 41). Soil No. 614 has produced exceedingly good crops of grain and manure is considered average Red River Valley soil. Soil No. 612 is a normal soil, but from higher ground, while No. 613 is similarly situated, which refuses to produce grain, only an occasional weed being found. Soil No. 612 is exceedingly rich in plant food, particularly in nitrogen and phosphoric acid. The soil is nearly 10 per cent. of lime and magnesium carbonates present. In the soil which refuses to produce crops abnormal amounts of soda and sulphuric anhydride are present in the form of sulphate of soda, a soluble compound which prevents the growth of vegetation. The presence of sulphate of soda was proved by analyzing the aqueous extract of the soil. In the productive soils the percentages of soda and sulphuric acid are materially less than in soil No. 613. Sulphate of soda is not as difficult and destructive as an "alkali" to deal with as carbonate of soda. Directions for the treatment of alkali soils are given in bulletin No. 41. These analyses have been of material value in determining the cause of the unproductiveness of the small areas of soil like No. 613, which are found occasionally in this fertile region.

Soil No. 569 (subsoil 570) from Kennedy, Kittson County, has produced eight crops of grain. This soil, like soils in general from the Red River Valley, is characteristically rich in nitrogen, phosphoric acid, potash and lime carbonate. The soil gives a slightly alkaline reaction, and while there is over 1 per cent. of potash present it is not in forms destructive to plant growth. A soil with .60 per cent of total nitrogen is not frequently met with, a high per cent. of nitrogen, however, is not an exception. It is a general feature of the Red River Valley soils. Lawes and Sturt, in the examination of the Red River Valley soils on the Canadian side, also report very high nitrogen percentages. The limestone and mildly alkaline salts, combined with remains of former vegetation, and a high per cent. of phosphoric acid are the factors which give these soils their high fertility.

Soil No. 611 from Park Rapids, Hubbard County, is a type of loam soil that contains a fair amount of plant food. The soil is one of considerable depth and its loamy character enables the crops to draw upon a relatively large amount of soil area for food purposes. In order to keep up the standard of fertility in a soil like No. 611, particular attention should be given to maintaining the humus by crop rotation and by the use of farm manures.

Soil No. 509 (subsoil 510) from Wyanett, Isanti County, is a sandy soil originally covered with mixed timber. It has produced good crops of potatoes and early vegetables. The future productiveness of soils like No. 509 depends entirely upon the way the land is farmed. Good crops of early market garden truck can be produced, providing the proper use is made of crops and manure.

Soil No. 579 (subsoil 580) from Becker Station, Sherburn County, has been cultivated twenty years, mainly to corn. The sandy surface soil is underlaid with clay at a depth of about four feet. While this soil does not contain high percentage amounts of plant food, it contains a greater total amount than some heavy clays, because its permeable nature brings the roots into contact with a larger area of soil than would be the case with heavy clay. This soil has never been manured, and its future

productiveness is greatly impaired because of the loss of which has necessarily resulted from the land being cont under the plow. Similar soils that have not produced on exclusively show larger amounts of nitrogen.

Soil No. 575 (subsoil 576) from near Little Falls, M County, has never been cultivated. The land is partially tim with white and red oak and some poplar, and produ heavy growth of native grass. The soil contains a fair of plant food in a well balanced form. In the surface soil a the lime is in the form of limestone. From the chemi mechanical analyses oats, timothy and grasses would seem the most suitable farm crops to be grown. The soil will up readily in the spring and can be made to produce good of garden truck. The chemical analysis does not show t to possess any vital weakness. It is richer in plant foo many soils now being cultivated.

Soils Nos. 540 (subsoil 541), 544 (subsoil 545), and 548 (subsoil 549) are from the farm of the Grand Rapids Subs The farm contains a variety of soil types and these samp from the plots used for experimental purposes. Soil No. 540 and subsoil No. 549 give slightly acid reactions, while Nos. 544 and 545 are neutral. Soil No. 544 contains the most plant f the best balanced form. Since these soils are to be subje careful experimental tests, a better opportunity will be affor discuss their composition and comparative crop producing i in future bulletins.

Soils Nos. 600 (subsoil 601) and 602 (subsoil 603) fr Cloud, Stearns County, have been cultivated for seven an years, respectively. Soil No. 600 contains a better st volatile matter and nitrogen than soil No. 602. The l water in subsoil No. 603 is from four to twelve feet fr surface, which enables crops grown upon this soil to have most inexhaustible supply of water. These soils have pr crops of corn, oats and potatoes. The chemical and mech composition of the soils would indicate that they are best a to the culture of early market garden truck. Soil No. 600 i suitable for general farming purposes than soil No. 602.

Soil No. 630 (subsoil 631) was originally covered with oak and has been cultivated thirty-five years, manure being used every five or six years. Fair crops of corn and small grains have been produced. The soil contains a good working supply of plant food. There is a good content of lime carbonate in both the surface and subsoil. The plant food appears to be in a balanced condition.

Soil No. 529 (subsoil 530) has produced fifteen crops of grain, vegetables and potatoes since the land was cleared of the native hardwood timber. There is a good supply of lime carbonate in both surface and subsoil, and a high content of phosphoric acid. The soil is amply supplied with plant food. In the subsoil there is somewhat less fine earth than in the surface soil; hence, it will be necessary to maintain a full content of humus in the surface soil so as to enable it to retain water and to prevent crops suffering from drought. This soil is particularly adapted to corn, oats, potatoes and vegetables, and will also produce good crops of grass and hay.

NOTES ON METHODS OF ANALYSIS.

The methods adopted by the Association of Official Agricultural Chemists were used in making the soil analyses reported in this Bulletin. The acid digestion however, was carried on for thirty-six hours instead of ten. Particular attention was given to the lime, potash, phosphoric acid and nitrogen determinations. The lime was precipitated in the usual way, but instead of weighing as carbonate (?) the lime was dissolved and titrated with standard potassium permanganate. The potash was redissolved and weighed according to the method described by Fresenius; this was found necessary because the impurities in many cases were found to influence the results. The separation and determination of the potash are the most troublesome problems in soil analysis.

In the determination of the phosphoric acid, the disturbing influence of alumina was frequently observed, and it was necessary in many cases to modify the usual process so as to remove the alumina. In some soils, particularly those with large amounts of organic matter the hydrochloric acid failed to remove all of the

phosphoric acid because of the insoluble combinations of mus and phosphoric acid. In such cases sulphuric acid proposed by Goss was used. The nitrogen determination made in the usual way, except that copper flasks were used distillation because of the frequent losses by breakage. The amount of insoluble residue from soils causes frequent from breakage of distilling flasks. Many of the analyses made in duplicate, particularly the nitrogen, phosphoric acid, ash and lime determinations. All results are given on the basis of "dry soil" and not "air dry soil."

TABLE II.—Chemical Composition of Soil.

LOCALITY, &c.	Dakota Co. Castle Rock.		Dakota Co., Castle Rock.		Dakota Co. Eureka.		Dakota Co. Lakerville.		Goodhue Co. Holden.		Goodhue Co. Holden.	
	563 Surface	564 Sub.	557 Surface	558 Sub.	585 Surface	586 Sub.	513 Surface	514 Sub.	553 Surface	554 Sub.	521 Surface	522 Sub.
Number of soil.....	74.1	70.3	74.1	77.8	74.1	.....	67.04	66.6	74.1	72.2	.....	.....
Kind of soil.....	99.7	99.5	99.5	99.8	95.	.....	90.	91.	99.4	100.	99.5	99.8
Weight per cubic foot.....	.8	.5	.5	.2	5.	.....	10.	9.	.2	.....	.5	.7
Fine earth.....	3.99	.....	3.62	.....	4.01	.....	4.12	.....	4.29	.....	4.17	1.59
Skeleton.....	.24	.14	.23	.12	.26	.....	.31	.18	.24	.10	.22	.09
Humus.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total nitrogen.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
CHEMICAL ANALYSIS—(HCl 1.115 sp. gr.)												
Total insoluble matter.....	82.85	84.30	84.68	86.33	66.98	71.44	82.09	82.05	82.80	84.02	84.20	84.50
Potash.....	.42	.35	.29	.31	.44	.24	.28	.22	.40	.46	.48	.38
Soda.....	.49	.48	.38	.42	.....	.....	.08	.10	.35	.54	.49	.31
Lime.....	.41	.29	.38	.25	.46	.27	.58	.44	.64	.48	.69	.44
Magnesia.....	.40	.42	.34	.39	.25	.26	.69	.72	.70	.78	.61	.78
Ferric oxide and alumina.....	6.15	5.61	6.47	7.33	19.78	19.17	7.60	8.42	5.96	9.35	6.79	8.91
Phosphoric anhydrid.....	.19	.20	.16	.12	.16	.12	.36	.33	.17	.12	.16	.11
Sulphuric anhydrid.....	.08	.07	.17	.03	.09	.08	.10	.05	.08	.04	.06	.04
Carbonic anhydrid.....	.08	.11	.08	.03	.01	.32	.03	.04	.11	.11	.14	.15
Total volatile matter.....	8.41	5.58	7.48	5.98	9.31	7.77	10.47	7.15	8.20	4.82	8.04	4.64

TABLE III.—Chemical Composition of Soils.

LOCALITY.	Goodhue Co. Kenyon.	Goodhue Co. Cannon Falls.	Goodhue Co. Zumbrota.	Goodhue Co. Red Wing.	Goodhue Co. Stanton.	Goodhue Co. Stanton.
Number of soil.....	527	616	555	577	578	572
Kind of soil.....	Surface	Sub.	Sub.	Surface	Sub.	Surface
Weight per cubic foot.....	68.4	97.3	74.1	100.	94.	98.5
Fine earth.....	96.	98.1	99.7	100.	94.	94.5
Skeleton.....	5.	2.7	3	3.59	6.	5.5
Humus.....	5.31	2.19	2.39	.24	4.	4.71
Total nitrogen.....	.32	.14	.17	.06	.24	.30
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)						
Total insoluble matter.....	78.02	87.70	86.69	82.49	81.72	79.82
Potash.....	.51	.50	.44	.38	.37	.43
Soda.....	.85	.29	.37	.12	.33	.57
Lime.....	.70	.56	.50	.42	.51	.51
Magnesia.....	.76	.28	.63	.51	.68	.79
Ferric oxide and alumina.....	9.67	6.98	6.16	8.11	7.91	9.46
Phosphoric anhydrid.....	.20	.16	.19	.16	.15	.37
Sulphuric anhydrid.....	.07	.07	.08	.09	.08	.17
Carbonic anhydrid.....	.02	.07	.19	.01	.20	.09
Total volatile matter.....	10.18	4.95	5.67	7.87	8.82	10.29

TABLE IV.—Chemical Composition of Soil.

LOCALITY.	Hennepin Co. Bloomington.		Wabasha Co. Hammond.		Wabasha Co. Kellogg.		Wabasha Co. Lake City.		Winona County. Stockton.	
	542 Surface	543 Sub.	515 Surface	516 Sub.	618 Surface	619 Sub.	503 Surface	504 Sub.	596 Surface	597 Surface
Number of soil.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kind of soil.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Weight per cubic foot.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fine earth.....	4.80	.....	.....	.....	85.5	85.5	100	100	100	100
Skeleton.....	.26	.12	.....	.....	14.8	34.7	.....	.....	.....	.....
Humus.....	.....	.....	.....	.....	3.85	.....	.....	.....	.....	.....
Total nitrogen.....	.....	.....	.31	.18	.24	.15	.16	.05	.13	2.64 .18
CHEMICAL ANALYSIS—(HCl., 1.115 sp. gr.)										
Total insoluble matter.....	81.99	85.40	86.21	86.40	81.13	84.83	86.78	85.90	87.97	85.79
Potash.....	.53	.31	.20	.20	.54	.41	.20	.20	.38	.46
Soda.....	.23	.26	.16	.17	.33	.33	.14	.27	.26	.33
Lime.....	.42	.24	.34	.37	.41	.16	.49	.46	.48	.52
Magnesia.....	.41	.48	.72	.97	.10	.20	.44	.44	.51	.45
Ferric oxide and alumina.....	7.58	7.98	5.06	6.70	9.96	8.44	6.13	8.66	5.96	5.04
Phosphoric anhydrid.....	.23	.33	.31	.35	.22	.21	.34	.34	.13	.26
Sulphuric anhydrid.....	.08	.06	.03	.04	.09	.08	.08	.04	.06	.03
Carbonic anhydrid.....	.16	.06	.06	.07	.02	.02	.05	.04	.05	.04
Total volatile matter.....	8.98	5.62	6.45	4.21	8.46	5.93	5.67	3.53	4.21	5.61
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	80.46
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.44
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.31
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.69
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.17
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.47
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.18
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.06
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.04
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.71

TABLE VII.—Chemical Composition of Soils.

LOCALITY.	Martin Co. Fairmount.		Watonwan Co. Madella.		Watonwan Co. Madella.		Watonwan Co. Madella.		Nicollet Co. Noreland.	
	561 Surface	562 Sub	531 Surface	532 Sub	606 Surface	607 Surface	605 Sub	608 Surface	523 Surface	524 Sub
Number of soil.....	72.2	78.8	77.8	73.2	.....	100.	99.5	99.5	96.8	95.8
Kind of soil.....	97.	97.	90.8	85.5	.....	.....	.....	.....	8.2	4.2
Weight per cubic foot.....	8.	3.	9.2	14.5	1.	.....	.5	.5	.....	.....
Fine earth.....	8.28	.....	4.11	3.24	1.89	2.80	.....	4.41	6.83	4.76
Skeleton.....	.....	.....	.....	.....	.....	.20	.05	.....	.....	.....
Humus.....	.....	.....	.29	.20	.13	.....	.....	.....	.....	.....
Total nitrogen.....	.22	.09	.....	.....	.....	.....	.....	.....	.....	.22
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)										
Total insoluble matter.....	82.20	82.60	80.17	80.12	91.38	88.02	91.78	78.89	78.15	80.98
Potash.....	.57	.39	.49	.40	.45	.36	.37	.46	.52	.49
Soda.....	.37	.65	.....	.....	.33	.22	.24	.40	.15	.27
Lime.....	.93	2.08	.81	1.95	.40	.77	.62	2.55	.62	.71
Magnesia.....	.76	.84	.54	.86	.17	.37	.15	.20	.73	.79
Ferric oxide and alumina.....	7.35	7.69	8.05	8.38	4.81	4.86	4.48	6.23	8.47	8.26
Phosphoric anhydrid.....	.11	.12	.15	.12	.19	.10	.19	.24	.20	.15
Sulphuric anhydrid.....	.06	.03	.08	.09	.06	.07	.09	.16	.08	.06
Carbonic anhydrid.....	.29	1.21	.29	1.09	.07	.27	.28	1.19	.17	.17
Total volatile matter.....	7.43	4.77	9.06	5.54	.....	.....	.....	.....	11.83	8.10

TABLE VIII.—Chemical Composition of Soils.

LOCALITY.	Sibley Co.		Renville Co.		Lyon Co.		LacquiParleCo.		Bigstone Co.		Kandiyohi Co.	
	Winthrop.		Sacred Heart.		Lynd.		Marlet & Dawson.		Bigstone.		Wilmar.	
Number of soil.....	559	560	511	512	599	600	565a	502	537	538	624	625
Kind of soil.....	Surface	Sub	Surface	Sub	Surface	Sub	Surface	Surface	Surface	Sub	Surface	Sub
Weight per cubic foot.....	74.	72.2	62.8	68.4	.....	.....	.....	.....	65.5	74.	89.	76.5
Fine earth.....	96.5	92.	98.	99.	.....	.....	.....	99.	97.0	96.0	11.	23.5
Skeleton.....	3.5	8.	2.	1.	3.24	.....	.....	1.	3.0	5.0	4.58	.....
Humus.....	4.43	.....	4.12	.....	.....	.....	.....	4.65	4.75	.....	.....	.....
Total nitrogen.....	.29	.07	.35	.11	.18	.04	.....	.42	.23	.08	.34	.12
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)												
Total insoluble matter.....	80.38	82.03	77.52	82.59	80.25	67.54	52.38	72.12	76.81	79.45	77.95	70.25
Potash.....	.43	.34	.42	.30	.56	.91	.50	.54	.35	.48	.68	.50
Soda.....	.69	.44	.17	.14	.25	.25	1.48	.41	.....	.....	.22	.51
Lime.....	.63	1.74	.97	1.03	.57	4.38	14.00	1.65	.68	1.21	1.42	12.31
Magnesia.....	.45	1.07	.60	.65	.67	6.88	1.33	.67	.73	1.05	.38	.68
Ferric oxide and alumina.....	7.69	8.81	8.74	9.95	8.92	11.01	8.95	8.31	6.67	7.88	8.54	.....
Phosphoric anhydrid.....	.16	.10	.32	.26	.24	.26	.19	.29	.20	.11	.20	.11
Sulphuric anhydrid.....	.07	.05	.04	.09	.24	.07	6.03	.11	.17	.07	.16	.10
Carbonic anhydrid.....	.12	1.32	.13	.40	.10	8.20	2.49	1.18	.05	.80	.18	10.83
Total volatile matter.....	9.33	4.07	10.64	4.88	.....	.....	6.98	13.84	12.87	6.65	11.78	3.68

TABLE IX.—Chemical Composition of Soils.

LOCALITY.	Kandiyohi Co. Pennock.	Kandiyohi Co. Pennock.	Kandiyohi Co. Lintonville.	Swift Co. Benson.	Swift Co. Hegbert.	Pope Co. Starbuck.
Number of soil.....	588	590	620	609	525	551
Kind of soil.....	Surface	Surface	Surface	Surface	Surface	Surface
Weight per cubic foot.....	96.	99.5	88.2	70.8	74.1	76.9
Fine earth.....	5.	.5	11.8	36.7	87.	97.
Skeleton.....	4.02	4.95	27.8	3.3	13.	3.
Humus.....	.26	.44	6.08	6.62	1.37	4.73
Total nitrogen.....	.15	.15	.39	.24	.41	.34
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)						
Total insoluble matter.....	83.97	78.12	80.11	83.81	78.90	61.90
Potash.....	34.	.52	.39	.33	.81	.57
Soda.....	12.	.48	.32	.14	.86	.71
Lime.....	40.	1.31	.87	.68	12.08	74.
Magnesia.....	5.99	.66	6.71	.33	2.97	.68
Ferric oxide and alumina.....	7.16	4.72	6.71	2.11	4.05	8.17
Phosphoric anhydrid.....	.14	.10	.21	.24	6.06	9.45
Sulphuric anhydrid.....	.07	.18	.16	.11	.12	.19
Carbonic anhydrid.....	.15	.22	.12	.40	.05	.12
Total volatile matter.....	8.45	5.41	10.93	10.02	9.22	11.07
			8.10		6.28	7.06

TABLE X.—Chemical Composition of Soils.

LOCALITY.	Otter Tail Co. Pelican Rapids.		Otter Tail Co. Vining		Becker Co.		Norman Co. Lockhart.		Norman Co. Lockhart.		Kittson Co. Kennedy.		Hubbard Co. Park Rapids.	
	517 Surface	518 Sub. 72.2	632 Surface	571 Surface	612 Surface	613 Surface	614 Surface	615 Sub.	569 Surface	570 Sub.	611 Surface			
Number of soil.....	95.6	90.8	86	98	.....	.....	.....	.....	99	98	.....			
Kind of soil.....	4.4	9.2	14	2	.....	.....	.....	.....	1	2	.....			
Weight per cubic foot.....	4.35	2.87	2.86	6.48	6.01	.....	3.5	.....	6.66	.....	1.53			
Pine earth.....	.25	.12	.18	.43	.67	.....	.32	.07	.60	.39	.12			
Skeleton.....														
Humus.....														
Total nitrogen.....														
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)														
Total insoluble matter.....	79.51	85.31	88.96	71.69	80.52	47.71	76.51	54.97	61.71	62.09	91.70			
Potash.....	.51	.77	.44	.73	.86	.90	.73	.76	1.16	1.18	.20			
Soda.....	.....	.....	.15	.56	.82	1.56	.93	1.89	.98	1.21	.19			
Lime.....	.97	.76	.71	.89	4.60	8.67	1.10	11.94	1.25	1.39	.48			
Magnesia.....	.61	.69	.25	.76	2.00	1.69	.60	.51	.58	1.63	.25			
Ferric oxide and alumina.....	7.90	7.85	5.27	11.37	10.43	11.98	12.68	15.47	17.99	15.05	3.02			
Phosphoric anhydrid.....	.16	.11	.14	.16	.34	.32	.16	.21	.19	.32	.04			
Sulphuric anhydrid.....	.09	.04	.08	.14	.24	2.91	.10	.07	.14	.12	.07			
Carbonic anhydrid.....	1.45	.95	.25	.05	3.97	8.19	.68	9.95	.11	.17	.....			
Total volatile matter.....	6.15	4.41	3.75	13.98	15.39	.....	6.34	5.65	17.27	16.74	4.64			

TABLE XI.—Chemical Composition of Soils.

LOCALITY.	Isanti Co. Wyant.		Sherburne Co. Becker.		Morrison Co. Little Falls.		Itasca Co. Grand Rapids.		Itasca Co. Grand Rapids.		Itasca Co. Grand Rapids.	
	509	510	579	580	575	576	540	541	544	545	548	549
Number of soil.....	Surface	Sub.	Surface	Sub.	Surface	Sub.	Surface	Sub.	Surface	Sub.	Surface	Sub.
Kind of soil.....	83.	85.3	92.5	95.	98.	72.5	81.6	100.3	70.3	66.5	85.3	100.3
Weight per cubic foot..	98.	98.	98.5	95.	98.	72.5	95.	94.	92.5	98.	99.	99.
Pine earth.....	2.	2.	1.5	5.	2.	27.5	5.	6.	7.5	2.	1.	.....
Skeleton.....	.....	.....	1.47	.....	1.98	.....	1.61	.....	.....	.....	.....	.....
Humus.....	.....	.....	.09	.05	.14	.06	.07	.04	.15	.08	.13	.....
Total nitrogen.....	.08	.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
CHEMICAL ANALYSIS (HCl. 1.115 sp. gr.)												
Total insoluble matter.....	93.66	96.19	94.27	95.66	89.00	91.34	92.34	93.79	80.82	84.36	92.83	93.31
Potash.....	.10	.10	.18	.22	.23	.21	.15	.13	.55	.46	.18	.27
Soda.....	.13	.12	.19	.21	.33	.23	.35	.11	.80	.66	.59	.29
Lime.....	.38	.33	.29	.34	.44	.36	.42	.28	.74	.90	.19	.29
Magnesia.....	.29	.27	.21	.21	.34	.31	.30	.35	1.04	1.14	.22	.34
Ferric oxide and alumina.....	2.99	2.88	2.22	2.30	5.34	5.41	2.87	3.67	9.23	8.92	2.94	3.49
Phosphoric anhydrid.....	.23	.22	.11	.07	.14	.07	.11	.09	.07	.14	.13	.10
Sulphuric anhydrid.....	.03	.03	.06	.07	.04	.04	.02	.03	.06	.06	.05	.06
Carbonic anhydrid.....	.01	.01	.01	.01	.09	.01	.05	.12	.09	.05	.04	.02
Total volatile matter.....	2.41	1.14	2.83	1.43	4.16	2.22	3.86	1.44	7.29	3.87	3.69	1.61

THE MECHANICAL COMPOSITION OF SOILS

HARRY SNYDER.

In addition to the chemical analyses, mechanical analyses have been made of the principal soil types of the state. The object of a chemical analysis is to determine the percentage amount of the various elements and simpler compounds of which a soil is composed. In a mechanical analysis the aim is to separate the soil particles into different grades as sand, silt, and clay, and to determine the percentage amount of each grade of particles. A study of the chemical composition of a soil deals mainly with the form and amount of plant food, while a study of the mechanical composition relates more to the physical properties, as resistance of the soil to water, and influences of heat and cold. When both the chemical and the mechanical composition of a soil are jointly considered more valuable results are secured than when each is separately considered.

The physical properties of a soil, as capacity for storing water, permeability, and resistance offered to implements, are determined largely by the number and size of the soil particles. It has been estimated that a gram of clay soil (a five cent weight weighs five grams) contains 20,000,000,000 soil particles, while a similar amount of sandy soil contains from 2,500,000,000 to 3,000,000,000 or more particles. Since the water which a soil contains is held either as a film upon the surface or in the capillary spaces between the soil particles, it naturally follows that the amount of water which a soil is capable of containing, as also its ability to retain this water, is dependent upon the number, size, and shape of the soil particles and their relation to each other.

Ordinarily soils are described as sand, clay, or loam, according

to the prevailing kinds of particles present. In a mechanical analysis the particles are divided according to size into six grades as follows:

	Size in Inches.	Size in Millimeters.
Coarse sand or skeleton	.04 to .02	1. to .5
Medium sand.....	.02 " .01	.5 " .25
Fine sand.....	.01 " .004	.25 " .10
Very fine sand.....	.004 " .002	.10 " .05
Silt.....	.002 " .0002	.05 " .005
Clay.....	.0002 and less	.005 and less

This division is purely an arbitrary one, and while it is of value in many ways it is hoped that a division founded upon some rational basis will in the near future be adopted and used.

The separation of the three grades of sand is effected by means of sieves with holes .5, .25, and .1 millimeters in diameter. In this

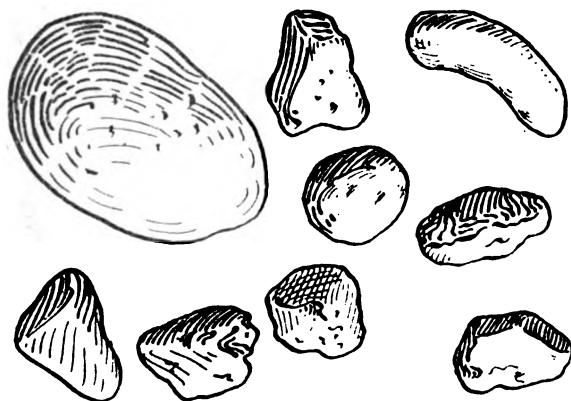


Fig. No. 1. Pebble Stones. Natural size.

work the very fine sand, silt and clay were separated by centrifugal force and sedimentation—a very slow process. The microscope was used to determine when the separations were reasonably complete. An absolute separation into the different grades of particles can only be approximated in practice. Invariably some of the fine clay adheres to the coarse particles, or

some of the larger particles refuse to be separated from the larger ones. The methods employed in the mechanical analysis of soils do not allow of absolute separations. While the percentage results equal 100 there is always more or less overlapping of different groups of particles.

Soils which contain appreciable amounts of clay, lime carbonate and vegetable matter are difficult to analyze, inasmuch as a cement-like mixture is formed which will not allow separation because of the cement-like nature of the material. The mechanical analyses reported in this article were made during the summer of 1895. The separation of the silt and clay of some of the soils frequently required a week's time and then the microscope failed to show as complete a separation as could be desired. In fact the methods employed for the mechanical analysis of soils do not admit of the same degree of accuracy as the methods employed for the chemical analysis.

Clay.—The term clay as used in the physical analysis of soils applies to those microscopic particles .5 m.m. (.0002 of an



Fig. No 2. Soil Particles X 325 times.

or less in diameter. The physical properties of clay are well known. The clay in a soil may be looked upon as the "binding material" or the particles which fit in between the grains of sand, making a more compact mass capable of holding a larger amount of water. A certain amount of clay is very desirable, but if a soil contains too much (50 per cent.), poor drainage results and the soil is a difficult one to work.

Silt.—The silt particles are those which are a size larger than the clay. The fine particles found in drains where water moves very slowly are mainly silt. Silt is between sand and clay in properties, and also acts as a binding material although it does not form as compact a mass as clay. A mixture of clay and silt is in many respects more desirable than either pure clay or pure silt. Many of the subsoils of this state, which are clay-like in character, are composed mainly of silt.

Sand.—In the tables, four grades of sand are given, the diameter of the largest sized coarse sand particles being twenty times that of the very fine sand. The fine and very fine sand impart desirable properties to the soil. When the fine and very fine sand are imbedded in silt and clay a mixture is formed which is easily tilled, retentive of water, and offers the least resistance to the growth of the roots of crops.

INTERPRETATION OF RESULTS.

When examining the results of a mechanical soil analysis, the relation existing between the sand, silt, and clay particles should be considered, rather than the percentage amounts of each individual ingredient. For example, a prairie soil containing 10 per cent. clay, 40 per cent silt, and 30 per cent. of fine and very fine sand is equally as suitable for corn production as one containing 18 per cent. clay, 25 per cent. silt and 37 per cent. of fine and very fine sand. The large and small particles in these two soils will form masses which have very similar physical properties. The small amount of clay in the one soil is compensated for by a larger amount of silt and less sand. Infallible rules for the interpretation of the results of the mechanical analyses, applicable to

all kinds of soil, cannot be given, because there are so many modifying factors which are capable of influencing the results. To illustrate, two soils may have nearly the same mechanical composition, but if one soil contains 3 per cent. or more of lime a modifying factor is introduced. The lime causes the large and small particles to cement and form more compact masses. Soil No. 568a, containing a large amount of gypsum, may be cited as an extreme case where an excess of lime sulphate imparts undesirable properties. In many of the prairie soils carbonate of lime is present to the extent of .50 per cent. or more. The lime is in a fine state of division and exerts a greater modifying influence upon the physical properties than if some inert ingredient were present to the same extent. The amount of organic matter which a soil contains also influences the physical properties. It is evident that the various modifying factors, as lime and organic matter, render it extremely difficult to determine from the mechanical analysis alone the kind of crops that the soil is best suited to produce. The silt subsoils of this state possess unique physical properties. Having the desirable features of both sand and clay they are able to produce a great variety of crops. In the tables Nos. X and XIV the type of soil is determined from the crops produced and not from fixed standards. It is believed that a larger amount of data should be available before the establishment of soil types for the state is undertaken. In the tables mechanical analyses are given of twenty-eight subsoils from different parts of the state. The subsoils were analyzed in preference to the surface soils, because storage capacity for water is more dependent upon the subsoil than upon the surface soil.

Subsoil No. 564 is from Castle Rock, Dakota County. The soil has produced good crops of small grain, corn, flax and clover. The subsoil is a mixture of nearly equal parts of the finest grades of sand, silt and clay. Good crops of wheat have been produced. The chemical analysis shows a liberal amount of plant food in well balanced forms, while the mechanical analysis shows a mixture of sand, silt, and clay that is retentive of water, and at the same time sufficiently porous to allow good drainage. Subsoil

No. 558 is from the same locality as No. 564, and has the same general chemical composition, but contains about 10 per cent. more silt and 12.50 per cent. less clay. The soil has produced crops similar to No. 564, and has shown a tendency to produce good yields of small grain, corn, and flax.

Subsoil No. 536 from the town of Eureka, Dakota County, has produced good crops of small grain and clover. The soil has about the same mechanical composition as No. 558, and is characterized by a high per cent. of silt. While the subsoil contains only 14.31 per cent. of clay, reasonably good crops of wheat and grain have been produced. Ordinarily a subsoil with such a relatively low per cent. of clay would not be considered a desirable one for wheat culture.

Subsoil No. 514 from Lakeville, Dakota County, contains more sand than the preceding samples and is characterized by a high content of silt. Good crops of corn, small grains (including wheat) and clover and grasses have been produced. The silt, sand and clay are present in such a proportion that the soil is suitable mechanically for the production of a great variety of crops.

Subsoil No. 574 from Stanton, Goodhue County, is composed mainly of silt, with smaller amounts of very fine sand and clay. Lime is a characteristic ingredient of the soil and the chemical analysis shows a good supply of plant food. The surface soil from near the same locality contains more clay and less silt than the subsoil. When the surface and subsoil show a mechanical structure like Nos. 572 and 574, unusual care should be taken in the cultivation to prevent unnecessary losses of water. It should be the aim to prevent evaporation by practicing frequent surface cultivation, and to keep the subsoil sufficiently compacted to prevent losses by percolation.

Subsoil No. 554, Holden, Goodhue County, has been cultivated to wheat, oats, barley and corn. There is a very high per cent of fine silt in this soil, which with the clay enables a larger amount of water to be retained than if less fine silt and more sand were present. During the first few years of cultivation large yields of wheat were produced. After the first fifteen years or so of

wheat culture lighter yields were obtained, but heavier crops of barley were secured than when the land was first broken. It has been quite a common experience in Southern Minnesota for the farmer to produce better crops of barley after a number of wheat crops have been removed than when the barley was grown first on the land. It is believed that this is due to the chemical and physical changes which have taken place in the soil. The continued growing of grain has a tendency to make the soil more open and porous. Wheat thrives best upon a compact soil, while barley prefers a loose soil. Wheat is a more delicate feeding crop than barley. Hence, with the loosening up of the soil and the removal of the most available plant food the conditions are more favorable for barley and less favorable for wheat.

Subsoil No. 556 from Zumbrota, Goodhue County, has produced good crops of wheat. There is more clay and less silt than is found in many of the soils from this locality. The lime content of plant food, and the mechanical condition all indicate a productive soil. The chemical analysis, however, shows a tendency to a decline in nitrogen and humus, which can be prevented by a change in methods of cropping.

Subsoil No. 578 from Red Wing, Goodhue County, contains a very high per cent. of clay, 44.22. The farmer's report is that "the soil has never suffered much from drought." The soil contains about 75 per cent. of clay and silt mixed with about 20 per cent. of very fine sand. This combination appears to be one possessing great power for storing up water and resisting drought.

Subsoil No. 528 from Kenyon, Goodhue County, has produced mostly wheat and oats. Silt, clay, and very fine sand are present to the extent of 80 per cent. The owner's report stated that the soil was very sticky. The soil does not belong to the heavy class, the "stickiness" is in part due to the alkaline compounds present. The chemical and mechanical composition suggests that this soil is more suitable for the production of wheat and oats than for oats, which have been grown extensively.

Subsoil No. 504 from Lake City, Wabasha County, contains

32.51 per cent. of clay and 49 per cent. of silt. The soil is retentive of moisture and easily tilled. It has produced wheat, oats, barley, corn and grass. Mechanically the soil is of good composition, chemically it could be improved by the addition of nitrogen.

Subsoil No. 506 from Alma City, Waseca County, contains nearly 48.50 per cent. of fine and very fine sand. The mechanical analysis indicates that the soil is particularly suited to corn production, since there is more sand and less clay and silt than are found in the heavy wheat soils.

Subsoil No. 568 from Moscow, Freeborn County, has produced wheat, oats, barley and corn in rotation, an application of manure being made to each corn crop. The soil has a well balanced mechanical as well as chemical composition. The sand and clay per centages indicate that the subsoil has the desired physical properties for wheat and grain production.

Subsoil No. 520 from Oakland, Freeborn County, has been cultivated only a few years, but has given indications of being adapted to root and corn crops. The subsoil is composed largely of sand and silt with about 17 per cent. of clay. Mechanically considered the soil is suitable for flax, but the nitrogen per centage is rather too low to suggest any extended flax production. Mechanically the soil appears to be suitable for beet culture.

Subsoil No. 534 from Waltham, Watonwan County, is composed mainly of silt and clay, with about 26 per cent. sand. This subsoil is suitable for the production of small grains, particularly barley. There is sufficient clay and silt to retain enough water for the production of good crops of timothy and other grasses.

Subsoil No. 532 from St. James, Watonwan County, has a well balanced chemical composition, but would appear to be too deficient in clay for wheat and other grains. The 3 per cent. of limestone, however, enables the clay and silt to be more valuable than if there were 3 per cent. more clay present. The mechanical and chemical composition suggest that the soil is particularly suited to the production of sugar beets.

Subsoil, No. 562, from Fairmont, Martin County, is character-

istically rich in lime and plant food. Good crops of wheat, flax, clover and corn have been produced. The subsoil contains about 50 per cent. of clay and silt mixed with about 18 per cent. of fine sand. The limestone in the subsoil enables the clay and silt to be more retentive of water, and imparts other desirable properties. Many of the prairie soils are mechanically and chemically like this sample.

Subsoil No. 560 from Winthrop, Sibley County, is composed largely of silt; the limestone and the 15 per cent. of clay make the subsoil retentive of moisture, while the medium, fine and very fine sand are present in the right amounts to impart permeability. This soil has produced good crops of wheat, flax and corn. The large amount of plant food and the unique mechanical structure of the soil adapt it to the cultivation of a variety of crops.

Subsoil No. 512 from Sacred Heart, Renville County, has shown special adaptability to the production of wheat and corn. The subsoil is composed approximately of one-fourth each of clay and very fine sand and one-third silt. The limestone forms with the sand, silt, and clay a combination which is particularly suitable for the production of small grains and grasses. The soil has not only a good mechanical composition, but is also well supplied with plant food. The productiveness of this soil is due to both its mechanical and chemical composition. The mixture of sand, silt and clay renders the soil permeable without reducing the storage capacity for water, while the abundance of potash, phosphoric acid, nitrogen, and lime complete the requisite food conditions for crop production.

Subsoil No. 524 from Norseland, Nicollet County, contains about 10 per cent. more silt and 10 per cent. less clay than subsoil No. 512. Subsoil No. 524 has produced good crops of small grains and corn. There is an ample store of plant food and the mechanical composition suggests that the soil is better adapted to the production of corn than of wheat.

Subsoil No. 538 from Bigstone, Bigstone County, has produced wheat, flax, oats and millet. Ordinarily this soil would not be considered a good one for wheat production because of the re-

tively small amount of clay; the fine limestone, however, exerts a modifying influence, and enables the clay to be of more value than if there were only a minimum amount of lime present. Flax and corn appear to be the crops most suited to this soil.

Subsoil No. 526 from Hegbert, Swift County, gives good promise of being a strong wheat producing soil. While there is only about 15 per cent. of clay there is an abundance of limestone, which will help to impart the desirable physical properties for a wheat producing soil. The high per centage of plant food elements was discussed in the preceding article of this bulletin. This soil should also produce good crops of flax and small grains.

Subsoil No. 518 from Pelican Rapids, Otter Tail County, has produced eight crops of wheat. The sand, silt and clay are present in about the same proportions found in many of the wheat producing soils of the state. The soil has also a good store of lime and plant food.

Subsoil No. 552 from Starbuck, Pope County, has been cultivated mainly to wheat and corn. The sand, silt and clay form a mixture which chemically considered is well supplied with plant food and physically is adapted not only to the production of wheat but also to barley, oats and grass.

Subsoil No. 570 from Kennedy, Kittson County, is a typical wheat soil of the Red River Valley. The small amount of sand and the relatively large amounts of silt and clay are characteristic of this soil. If it were not for the limestone in the subsoil which binds the silt and clay and forms compound soil particles the soil would possess poor drainage capacity, but with the high per cent. of limestone the clay is prevented from forming an impervious mass. These soils may be worked when very wet and the large clods when dry are easily pulverized. Ordinarily a soil with such a large amount of clay and other fine materials would not admit of working when wet because of danger from puddling. The limestone and alkaline salts exert a great influence upon the physical properties of these soils. In fact, many cold, unproductive clays have the same mechanical composition as the Red River Valley soils, but the lime and alkaline salts impart desirable properties

which heavy clays do not possess. With these soils the chemical composition is a greater factor in fertility than is the mechanical composition.

Subsoil No. 576 from Little Falls, Morrison County, has never been cultivated. Its mechanical and chemical composition would suggest that potatoes, oats, timothy and roots would be desirable crops to produce.

Subsoil No. 580 from Sherburn, Becker County, has been cropped mainly to corn. The fine sand, very fine sand, silt and clay are present in about the same amounts as in the usual corn producing types of soil. The soil is permeable and is capable of storing up sufficient water for the growth of corn, oats, potatoes, timothy, and grass crops. The land has been cultivated too continually to corn, which has had a tendency to make it open and porous.

Subsoil No. 530 from Taylor's Falls, Chisago County, has shown a special adaptability to the production of vegetables and oats. There is about 25 per cent. of silt and clay, which enables the soil to carry 15 per cent. or more of available water. The frequent use of manure has kept up the supply of available plant food and has also improved the physical condition of the soil. The mechanical analysis indicates that the soil is specially adapted to the production of vegetables and small fruits.

MINERALOGICAL CHARACTER OF SOIL PARTICLES.

In the mechanical examination of the soil frequent use is made of the microscope. The fine and very fine sand were found to be composed mainly of silica. In the silt, feldspar and mica appeared to predominate, while the clay was in some cases pure kaolin. In all of the soils examined there were a large number of rock fragments and materials capable of being distinguished. The microscopic examinations showed that the drift soils of the state are a heterogeneous mass of rock fragments and minerals in various stages of disintegration.

The very fine sand and silt particles are irregular in form and

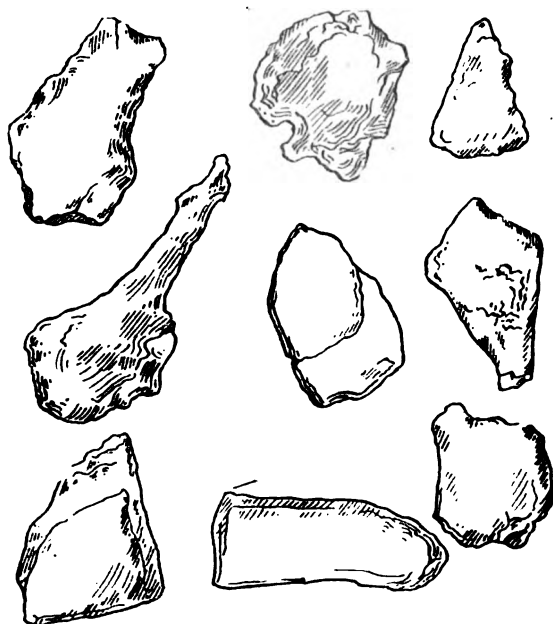


Fig. No. 3. Angular Silt Particles X 450 times. Prairie subsoil.

present sharp angles and show fissures and places where disintegration has taken place. Surrounding many of the larger grains of sand fine clay particles may be observed. The particles of the Red River Valley subsoil are less angular and more spherical than those of average prairie soil. The microscopical examination suggests that the *form* of the soil particles, as well as the size and number, is an important factor to consider, because in some soils the clay may be of greater or less value, according to the form of the other particles with which the clay is associated.

The influence of solvents upon the soil particles was also observed. After digestion with hydrochloric and other strong acids the angular appearance of the soil grains in many cases was more pronounced. The microscopical examinations indicate that strong acids act as solvents upon the surfaces only of the soil particles. In many of the fissures of the silt particles, fragments of vegetable matter could be observed indicating that the action of the humus

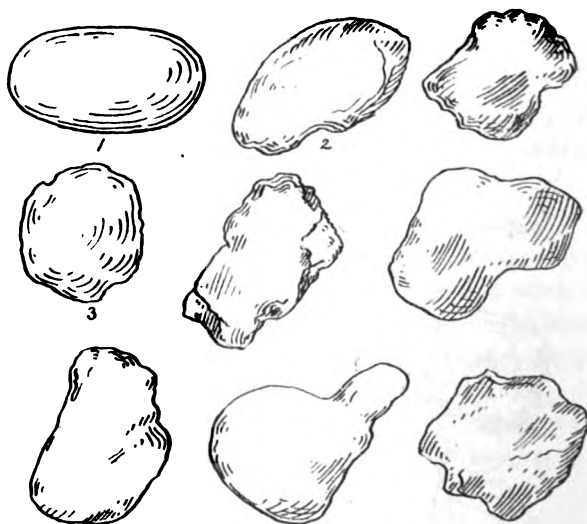


Fig. No. 4. Silt Particles X 450 times, Red River Valley subsoil.

upon the soil was most active in those places on the soil p where the greatest disintegration had taken place and whe sumably the most soluble forms of food are to be found.

SOIL PARTICLES AND SOIL MASSES.

Each separate particle of sand, silt or clay in the soil is tact with other particles, forming soil masses with definite p properties. The soil is either impervious to water or per and of good tilth, or open and porous according to the ch of the individual soil particles. The properties of the soil r formed from the soil particles, are frequently modified beca the presence of lime, alkaline compounds, and vegetable

The influence of lime upon the soil masses is shown in F 5. It will be observed that many of the soil masses are ab size of wheat kernels, while some are larger. The soil contain a small amount of sand but many of the smaller particles ar ed and form compound soil grains, which to a limited exte the place of the larger soil particles which are deficient. Th soils contain from 18 to 25 per cent. of carbonate of lime,

variable amount of alkaline salts. When the land dries the lime and alkaline matter prevent the formation of tough clods although the soil contains nearly 45 per cent. of fine clay. The lime makes

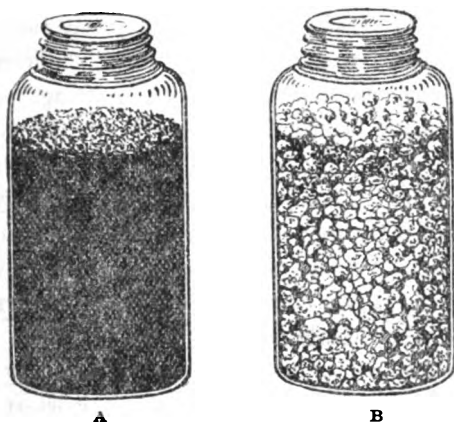


Fig. No. 5. Influence of lime upon soil. *A*, loam soil with 15 per cent clay particles. *B*, Red River Valley subsoil with 45 per cent clay particles. The lime causes the formation of compound soil grains,

the soil permeable, and the additional action of the alkaline matter makes them pulverulent when dry. In many of the prairie soils there is sufficient lime and alkaline matter to exert a characteristic influence and cause the formation of compound soil grains which give the soils unique physical properties.

The influence of the organic matter, in the form of humus, upon the physical properties of the soil, has been discussed in former bulletins. The chemical and physical analyses of the different types of soil recorded in this bulletin, have verified the main conclusions of former reports upon this subject. It has also been observed that a loss of the humus from loam and silt soils has been felt more severely than in the case of soils which contain a good supply of clay. Humus to a certain extent is capable of taking the place of fine clay.

In the presence of alkaline compounds the humus is chemically and physically different from that in soils deficient in alkaline matter. In many of the Red River Valley surface soils the "alkali" renders some of the humus soluble causing the drain waters

to be dark colored. In soils well supplied with alkaline the humus is more active than in soils which are deficient.

In the prairie soils the loss of humus is felt most in the swept regions. Soils "drift" more readily when they lose humus because there is a lack of binding material. The large and fine roots exert a modifying influence sufficiently great in many cases to prevent heavy losses by drifting. The physical changes which have been caused by heavy wind storms are frequently of such a magnitude as to influence the crop producing power of the land. Heavy wind storms frequently carry off large amounts of plant food. By conserving the humus and keeping the land well covered, the losses from heavy winds are greatly reduced. It is a common experience of farmers that old land will suffer more in a wind storm than new land.

The influence of humus upon the water supply of crops has been discussed in former bulletins. In this work it has been observed that fewer complaints from the effects of drought are made when the land had been systematically manured and the humus conserved. Immediate effects from the use of manure are not always to be expected as time is required for the manure to become humus. Often the physical treatment of the land after it is manured is such that the best results are not secured. The soil is left in a loose condition, or surface cultivation neglected so that excessive losses from evaporation occur. The influence of manure exerts upon the moisture content of the soil varies with the mechanical structure of the soil, and the amount of manure used. In some soils the influence is more noticeable than in others. The influence which manure has upon soils varies with the character of the soil particles and the condition of the manure. When mixed with the soil the manure forms masses with different physical properties, and when a chemical reaction takes place between the soil and the manure the soil masses are subjected to still farther modification. The individual soil particles change but little in physical properties, but the soil masses or "compounds" are constantly undergoing changes. Hence, it is evident that manure is capable of improving the physical properties of a

TABLE XIII.—The Mechanical Composition of Soils.

Sub- Soil No.	Location.	County.	Type of Soil.	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Silt	Clay	Volatile
564	Castle Rock...	Dakota...	Small grains and clover.....	0.50	0.89	14.20	15.71	34.53	28.48	5.69
558	Castle Rock...	Dakota...	Small grains and corn.....	0.20	2.93	18.94	12.43	44.21	15.89	5.40
536	Eureka.....	Dakota.....	Small grains and clover.....	.....	.....	15.31	14.08	48.21	14.31	8.09
514	Lakeville.....	Dakota.....	Corn, small grains and grass.....	9.00	.....	9.01	11.02	46.70	17.12	7.15
574	Stanton.....	Goodhue.....	Corn, flax and small grains.....	1.50	.....	2.27	20.27	56.17	15.47	4.32
572	Stanton.....	Goodhue.....	.....	5.50	3.27	8.50	25.34	16.07	31.02	1.30
554	Holden.....	Goodhue.....	Wheat, barley and corn.....	.....	.52	1.27	12.05	66.96	14.27	4.93
556	Zumbrota.....	Goodhue.....	Wheat, barley.....	1.00	1.00	0.08	9.10	47.73	37.98	3.71
578	Red Wing.....	Goodhue.....	Wheat, corn and grass.....	.....	.....	.....	19.36	30.58	44.22	5.84
528	Kenyon.....	Goodhue.....	Wheat and small grains.....	6.50	.....	6.46	20.10	34.27	25.65	7.02
504	Lake City.....	Wabasha.....	Wheat and small grains.....	.....	.....	.....	14.96	49.00	32.51	3.53
506	Alma City.....	Wabasha.....	Corn and small grains.....	4.00	.....	15.15	23.30	33.39	18.04	6.12
568	Moscow.....	Freeborn.....	Wheat.....	2.00	.....	2.95	14.94	43.92	31.18	5.01
520	Oakland.....	Freeborn.....	Roots and corn.....	11.00	0.35	16.62	13.82	36.73	17.36	4.12

TABLE XIV.—The Mechanical Composition of Soils.

Sub- Soil No.	Location.	County.	Type of Soil.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt.	Clay.	Volatile.
534	Waltham.....	Mower.....	Small grains and grass.....	11.00	2.25	2.87	9.60	47.73	20.61	5.94
532	St. James.....	Watsonwan.....	Flax, corn, wheat.....	14.50	.....	19.48	10.39	36.15	11.85	7.63
562	Fairmont.....	Martin.....	Wheat, clover, corn.....	3.00	2.24	18.18	20.64	29.40	20.56	5.98
560	Winthrop.....	Sibley.....	Wheat, flax, corn.....	8.00	2.77	9.93	5.78	52.79	15.34	6.39
512	Sacred Heart.....	Renville.....	Wheat, corn.....	1.00	.....	9.64	24.57	34.04	25.47	5.28
524	Norseland.....	Nicollet.....	Small grains and corn.....	4.20	.....	7.07	22.36	44.16	14.02	8.27
538	Bigstone.....	Bigstone.....	Corn and flax.....	5.00	3.77	33.51	12.90	22.99	14.58	9.25
526	Hegbert.....	Swift.....	Wheat.....	13.00	.....	8.44	5.30	42.77	14.99	15.50
518	Pelican Rapids.....	Otter Tail.....	Wheat.....	9.20	.....	9.86	8.76	41.22	25.60	5.36
552	Starbuck.....	Pope.....	Wheat and corn.....	2.00	.....	7.27	18.56	44.38	20.05	7.15
570	Kennedy.....	Kittson.....	Wheat.....	.....	.....	0.38	10.08	25.98	37.22	16.91
576	Little Falls.....	Morrison.....	.....	27.50	2.10	18.48	16.29	25.08	8.32	2.22
580	Becker.....	Sherburn.....	Corn.....	5.00	.....	34.93	20.96	23.51	14.17	1.43
530	Taylor's Falls.....	Chicago.....	Grain and vegetables.....	28.00	.....	28.10	15.00	13.82	11.75	3.33

THE AVAILABLE PLANT FOOD OF SOILS.

HARRY SNYDER.

Various attempts have been made to determine the available plant food of the soil. The main criticism which has been made regarding the value of soil analysis is that it fails to show the amount of available plant food. It is well known that a soil may contain a relatively large amount of potash and phosphoric acid soluble in acids and still fail to produce good crops because of lack of available plant food. This lack of available plant food, as discussed in the first article, is due in many cases to an unbalanced condition of the elements in the soil. The present tendency of soil investigations is to determine the "availability of the plant food." The various methods proposed may be classed in two groups: (1) The use of dilute acid solvents to extract the available plant food; and (2), the use of dilute alkaline solutions to replace the more active forms of potash.

Dilute acids, particularly the organic acids, have been used, because the sap in the roots of plants contains various amounts of organic acids as citric, tartaric, and oxalic; and it is believed that these acids take an important part in plant nutrition by rendering the plant food soluble. Dyer and others have shown that the acidity of the sap of agricultural plants is equivalent to from .5 to 2 per cent. or more of citric acid.

The acidity of the sap of a few of the agricultural crops grown at the Minnesota Experiment Station in 1898 was determined and the following equivalent amounts of acid obtained. The crops were tested while young, and when making rapid growth.

NOTE.—Some of the results given in this article were presented at the Columbus meeting (1899) of the Society for the Promotion of Agricultural Science.

	Acidity (As citric acid) Per cent.
Corn	.60
Oats	.92
Wheat	.48
Clover	1.02
Ky. Blue Grass	.88

It will be observed that the sap of wheat contains less than either oats or corn, while clover shows the highest acidity. Wheat is generally considered one of the weakest feeding crops.

In the seeds of ripe grains the average acidity has been found to be .10 per cent. and in roots and tubers about .20 per cent. No systematic attempt has yet been made to determine the precise amounts of the separate acids, as oxalic, malic, citric, tartaric, etc.

In a former bulletin (No. 41), the extent to which solutions of tartaric, oxalic, and citric acid are capable of acting upon the soil and dissolving plant food elements was discussed. It was found that a 1 per cent. solution of citric acid extracted .02 per cent. of potash and .04 per cent. of phosphoric acid from a common sample of soil made up of equal parts of two hundred fertile and infertile soils. It was also found that citric acid possessed the greatest power in dissolving phosphoric acid, lime and magnesia, while oxalic acid was capable of dissolving the most iron and alumina. Tartaric acid was less active as a soil solvent than either citric or oxalic acid. Prairie soils of high fertility contained .04 per cent of potash and like amount of phosphoric acid soluble in dilute citric acid. In none of the soils examined were the potash or phosphoric acid percentages less than .02.

Dyer has shown that the unmanured Rothamsted soil, which Lawes and Gilbert have made their numerous field experiments with wheat and barley, contain only .0055 per cent. of phosphoric acid soluble in 1 per cent. citric acid, while the soils which have been manured with phosphates until they are no longer deficient contain from .03 to .06 per cent. according to the amount of fertilizer applied to the land. In the case of the Rothamsted

the work of Dyer has shown that if there is less than .02 per cent. phosphoric acid soluble in a 1 per cent. solution of citric acid the soil is deficient in available phosphoric acid.

Dyer's method for the determination of available phosphoric acid has been tried by the Association of Official Agricultural Chemists and it has not been found applicable to all classes of soils. The method, however, was found in many cases to give valuable indications but it failed to make a sharp distinction between soils of different origin and character when deficient in and when well supplied with available phosphoric acid.

Plant Food Soluble in Citric Acid (Dyer's Method.)—Three samples of soil were selected for the determination of the available plant food according to Dyer's method. Soil A, virgin soil of high fertility from the Red River Valley. Similar cultivated soils have produced good yields of wheat and field tests have shown that the soil was amply supplied with available phosphoric acid and other forms of plant food. Soil B, virgin soil from the Minn. Experiment Station farm. Field tests have shown adjoining cultivated soils to be well supplied with available phosphates and other plant food, the soil has not been able to produce such good crops or stand as heavy cropping as the soils from the Red River Valley. Soil C, from an old grain field yielding only eight bushels of wheat per acre. It was not known whether the low yield per acre was due to lack of available phosphates or to some other cause. These three soils were selected as types for the study of the available plant food. The total and so-called available phosphoric acid are given in the following table:

	Soil A. Red River Valley. High Fertility.	Soil B. Exp. Station Farm. Average Fertility.	Soil C. Prairie Soil. Old Grain Field
Total phosphoric acid...	.23	.17	.15
Available (?) phos. acid..	.018	.021	.034

According to Dyer's method, the soil from the Experiment Station, and the one from the old grain field contain more available phosphoric acid than the fertile Red River Valley soil. Field tests, and crop yields, however, show that the Red River Valley

soil is the most liberally supplied with available phosphates, of these soils. According to the results secured on the hamsted soils, the Red River Valley sample would appear deficient in available phosphoric acid. It is evident that the method proposed by Dyer, is not applicable to soils like those found in the Red River Valley and the prairie regions of the state.

In addition to Dyer's method the one proposed by Goss was also tried. Goss' method is similar to Dyer's except that a normal solution of hydrochloric acid is used as a solvent for plant food instead of a 1 per cent. solution of citric acid. The total and so-called available phosphoric acid in soils *A*, *B*, and *C*, as determined by Goss' method are given in the following

	Soil A. Red River Valley. High Fertility.	Soil B. Exp. Station Farm. Average Fertility.	Soil C. Prairie Old Grass
Total phosphoric acid...	.23	.17	.18
Available (?) phos. acid..	.061	.032	.07

This method has given more consistent results than Dyer's method; the amounts of so-called available phosphoric acid are in accord with the known fertility of the soils. It cannot be said, however, that this method is capable of giving infallible results when applied to all classes of soils.

In addition to citric and fifth normal hydrochloric acid as acid solvents have been proposed. A review of the work accomplished and a study of each method was not attempted because the principle involved in each method is essentially the same. The amounts of plant food elements dissolved, however, vary with the solvent power of the reagents. It is supposed by some that it is possible by the use of dilute acids to imitate the action of plant roots. As to whether this can be accomplished remains to be proved.

In the case of both methods, (1) acid solvents, and (2) the placement of soil bases with alkaline solutions, the main difficulty arises when an attempt is made to establish a reasonable standard for available plant food. The usual method has been to

soils that field tests have shown to be deficient in plant food. But are field tests always reliable? May not an apparent deficiency in one element be due to some other cause than a real deficiency, as shown by the Rhode Island Experiment Station, where an acid condition of the soil was the cause of a supposed deficiency of available phosphoric acid, and the addition of alkaline matter to the soil rendered the phosphoric acid available? In such a case an agreement between laboratory results and field trials could not be expected, because the field tests gave misleading results.

Soils differ so materially in different parts of the country, and in some cases even in the same locality, from acid soils to those strongly charged with alkaline matter, that it cannot be expected that the same methods for the determination of available plant food are alike applicable to all classes of soils.

When an alkaline solution is used on acid soils, or an acid solution on alkaline soils, neutralization takes place, and as a result we have not only the action of the acid or alkali but also the action of the salts formed by the neutralization, and even if corrections are made for the acid neutralized by the carbonates the solvent action of the salts formed can not be prevented.

What assurance have we that a 1 per cent. solution of citric acid or a fifth normal solution of hydrochloric acid will extract only the available plant food from the soil; or that a dilute alkaline solution will replace only the available potash of the soil? If a soil that is reasonably well supplied with available phosphoric acid be extracted with a 1 per cent. solution of citric acid, will it leave in the soil a sufficient amount of available plant food to grow an ordinary crop? Let us briefly examine the details of such an experiment.

Soil *B* from the Minnesota Experiment Station farm was extracted with a 1 per cent. solution of citric acid for three months. This resulted in reducing the phosphoric acid content of the soil from .17 to .14 per cent., removing 17.6 per cent. of the most soluble, and what would be supposed to be the most available phosphoric acid, as well as 28.5 per cent. of the total

potash. A large quantity of soil was extracted, 10 c. c. of acid being used for each gram of soil. The acid was removed from the soil by the liberal use of distilled water. To prevent a bad condition of the soil .10 gm. of calcium carbonate was added to every 100 grams of soil and a small amount of nitrate of soda was also added so that crop growth would not be checked for lack of nitrogen. When wheat was sown in this soil normal vigorous plants were produced as shown in the illustration. Three separate trials, at different times, gave practically the same results.

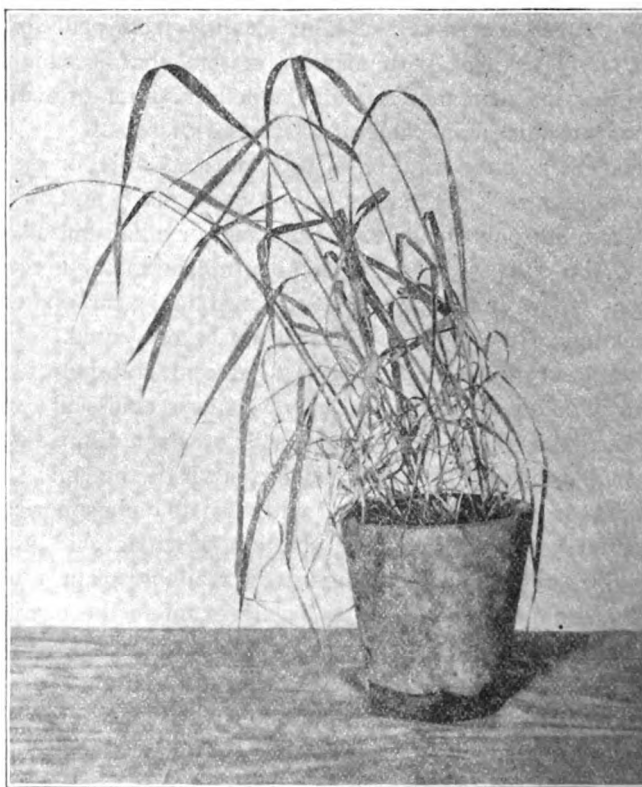


Fig. No. 6. Wheat grown in soil extracted with one per cent citric acid and 28.5 per cent. of the total phosphoric acid and 28.5 per cent. of the total potash of the soil were removed by the acid treatment.

The plants shown in the illustration contain the following amounts of potash and phosphoric acid.

	In Six Plants. Grams.	In Six Seeds Sown Estimated Amount.
Potash.....	.0625	.0011
Phosphoric acid.....	.0451	.0018

It is evident that the three months' extraction of the soil with citric acid failed to remove all of the available phosphoric acid and potash because a sufficient amount was left in the soil to produce a good growth of wheat.

The humus, phosphoric acid content of humus, and of humus precipitate, and the potash content of the soil before and after treatment with citric acid, are given in the following table:

	Original Soil.	Soil after Extraction and Growth of Wheat.
Total phosphoric acid.....	.17	.14
Total nitrogen.....	.23	.20
Humus	3.94	3.81
Humic phosphoric acid.....	.04	.04
P ₂ O ₅ of humic acid precipitate	.03	.03
Potash (Sol. Hcl. 1.115 Sp. gr.).....	.21	.15
Total insoluble matter.....	83.76	86.40

The three months' treatment of the soil resulted in the removal of a larger proportional amount of the potash than of the phosphoric acid. Only a slight change in the percentage amounts of humus in the soil before and after the treatment is to be observed, while the phosphoric acid content of the humus and the humic acid precipitate remain unchanged. When it is remembered that in the determination of humus, the soil is first extracted with 2 per cent. solution of hydrochloric acid to remove the lime, it can be understood why the humus content of the soil has changed but little during the three months treatment with citric acid. The phosphoric acid combined with the humus did not undergo any apparent change during the long extraction of the soil. The humic phosphates evidently have a material power

to resist the action of acid solvents, but readily yield to alkali solvents.

The experiment naturally suggests a few questions: Does not the citric acid cause some of the inactive phosphoric acid of the soil to become active? If it did this solvent cannot be taken as a standard for the measure of the active phosphoric acid of the soil because it would also include a small amount of inactive phosphoric acid.

The work of Schloesing, Jr., shows that beyond a certain point a dilute acid as nitric has no action upon a soil, and the amount of phosphoric acid in the solution is not increased until the concentration of the solvent is considerably increased. The phosphates of magnesium, calcium, and the alkali metals are dissolved by the dilute acids, while the stronger acids dissolve the phosphates of iron and alumina. Schloesing's work as well as the work of the International Congress of Chemists indicates that the action of a dilute acid upon a soil is definite.

That the citric acid did not change some of the available phosphoric acid of the soil to active forms and that the source of the plant's phosphoric acid was that combined with the organic substances was proven by direct experiment.

Two kilograms of soil *B* was extracted with dilute hydrochloric acid and the humus obtained in the usual way. The humus was dissolved and treated as described in bulletin No. 41, page 10. From the kilogram of soil 60 grams of purified humic matter were obtained. The humus was mixed with acid extracted from a small amount of carbonate of lime and nitrate of soda. When wheat was seeded in this medium, normal plants were produced. In a former report it was shown that oats are capable of being grown when the only forms of mineral food are those supplied in chemical combination with the humus. These experiments (1899) have shown that wheat is capable of assimilating similar forms of food. The fact that wheat is capable of assimilating the phosphoric acid and potash combined with humus was proved by three separate experiments. The plants presented a similar appearance to those shown in the illustrations.

The six wheat plants produced in the first experiment contained :

Phosphoric acid	.0401 grams
Potash	.0589 grams

In the soil from which the humus was extracted it is estimated that about 20 per cent. of the total phosphoric acid was in combination with the humus. From the experiments cited it is evident that the phosphoric acid and potash combined with the organic compounds of the soil are capable of playing an important role in the food supply of grains like oats and wheat.

The fact that the citric acid failed to remove all of the available phosphoric acid of the soil, and that a sufficient amount was left to produce a crop of wheat, naturally suggests the question, would a fifth normal solution of hydrochloric acid extract all of the available plant food? While direct experiments were not made, an answer to the question can be given.

When the humus was removed from the soil for the wheat culture experiments the soil was first extracted with a 2 per cent. solution of hydrochloric acid, which contains nearly three times as much acid as the fifth normal solution. If the 2 per cent. acid was used for getting the soil into condition for the extraction of the humus had removed all of the available phosphoric acid there would have been none left for the growth of the wheat, but the experiments show that the humus contains sufficient to produce a good crop hence it is evident that the hydrochloric acid like the citric acid failed to remove all of the available plant food. From the experiments performed it does not necessarily follow that the phosphoric acid extracted by the dilute citric and hydrochloric acid is unavailable but the experiments show that there was left in the soil, after the acid treatment, plant food in the form of potash and phosphates that could be utilized by a wheat crop, and that this plant food was in chemical combination with the organic compounds of the soil.

It is not claimed that the organic forms of potash and phosphoric acid are the only ones in which the plant food exists in the soil in an available condition, but it is evident that in the case of soils rich in organic matter, the organic compounds of potash and

phosphoric acid take an important part in plant growth. Dyer's and Goss' methods are, without doubt applicable to types of soil, but not to those where a large part of the food is in organic forms.

Available Potash.—The replacement of the potash by of alkaline solutions was also tried in the three soil types described. An alkaline solution of ammonium chlorid and a normal solution of calcium chloride were the solutions used. The following results were obtained:

	SOLUBLE In calcium chlorid.	POTASH In ammonium
Soil A. High fertility.....	.025	.07
Soil B. Average fertility....	.015	.02
Soil B. Old grain field.....	.021	.02

The ammonium chlorid method was given farther trial in connection with the soil work of the Association of Official Agricultural Chemists for 1898. The results obtained were not consistent. Soils known to be deficient in available potash gave lower percentage amounts of soluble potash than soils known to be well supplied with this element. (Proceedings 15th Annual Convention, Association Official Agricultural Chemists, page 5)

Citric acid as a solvent for the available potash also gave to give satisfactory results. The three soils examined gave the following results:

	Potash soluble in 1 per cent. citric acid.
Soil A High fertility	!..... .02
Soil B Average fertility	.01
Soil C Old grain field	.01

Soils *A* and *B* were also used for the soil investigation of the Association of Official Agricultural Chemists for the year 1898, and the results secured are of additional value because the same analyses were made by different analysts in eight soil experiment station laboratories.

AMOUNT OF AVAILABLE PLANT FOODS IN SOILS.

None of the methods investigated will allow a definite answer to the question: How much available plant food do the soils

ained contain? The culture experiment and the analyses, however, indicate that the soils used, particularly the Red River Valley and the station soil are, as the field tests indicate, well supplied with available potash and phosphoric acid. Soil *B*, of average fertility, contained in the first foot about 5,500 pounds of phosphoric acid and 6,700 pounds of potash. The treatment with citric acid removed 17.6 per cent. of the phosphoric acid and 28.5 per cent. of the potash, and there was still left in the soil sufficient mineral plant food to produce a crop of wheat. While it cannot be said that the plant food removed by the acid was all available it can be said that 17.6 per cent. of the phosphoric acid and 28.5 per cent. of the potash can be removed from the soil used, without removing all of the available plant food. The .04 per cent. of humic phosphoric acid equivalent to about 23 per cent. of the total was capable of producing a wheat crop. Since a large part, if not all, of the citrate soluble phosphates must have been in available forms as well as a large part of the humic phosphoric acid, it naturally follows that the total available amount in the soil must have been large. While the experiments failed to show that dilute acid solvent may be used to determine the available plant food, they nevertheless show that the humic or organic forms of potash and phosphoric acid may contribute materially to plant growth.

In a former bulletin (No. 53) it was proved that manure, green clover, and other organic materials are capable of entering into chemical combination with the inert phosphoric acid and potash of the soil, to form humates or organic salts. Since wheat and oats have both been found capable of assimilating the humic forms of potash and phosphoric acid, it is possible, if the soil contains a good stock of these elements, and is not of an acid nature, to use manures, and green crops, for rendering the inert plant food available. In fact it is possible by the use of farm manures to cultivate an average soil so as to produce available plant food from the inert matter.

CHARACTERISTIC FEATURES OF MINNESOTA SOILS AND CONSERVATION OF FERTILITY.

HARRY SNYDER.

One of the most important problems in agriculture is the conservation of the fertility of the soil. At the present time all of the soils of the state are well supplied with plant food; it is believed that if proper means are taken it will be possible to conserve, to a great extent, a large part of this fertility and prevent rapid decline in the yields of crops. Before discussing this subject it will be necessary first to consider the characteristic features of the soils of the state and the main facts observed in the analyses reported in this and former bulletins.

Numerous questions have been asked by the farmer. Why have we sent samples of soil for chemical analysis. Will this soil produce good crops, is frequently asked of a soil that has just been brought under cultivation. Will this soil wear well? Will crops will it pay best to grow on this soil? Is this a good soil for growing flax, or sugar beets, or some other farm crop? Why do some soils decline in fertility faster than others? Why do some crops ever refuse to grow on this soil? These are some of the questions that have been asked. While explicit answers cannot be given at the present time to all of the questions, the chemical analyses have given, it is believed, results of economic value.

It should be remembered that chemical and physical changes are continually taking place in the soil, and that in some soils these changes are more rapid than in others. In the cultivation of the soil it should be the aim to assist nature in bringing about the changes which render the plant food available. It frequently happens that the methods of nature and the methods of those

cultivate the soil are in direct opposition, when they should be in harmony. This is illustrated in the case of many soils from which large amounts of plant food in the form of nitrogen have been unnecessarily lost, because of poor methods of cultivation. It is natural for a soil to be covered with vegetation, and when the land is continually under the plow and only one crop is grown, an unnatural condition exists, and as a result there is a loss of fertility.

An ordinary crop removes a comparatively small portion of the total plant food of the soil, but a soil is capable of producing grain crops for only a few years before a decline in the yield per acre is observed. This is not due so much to the loss of fertility by the removal of nitrogen, phosphoric acid, potash, lime, and other elements from the soil, as to the soil getting out of condition because of chemical and physical changes which have taken place as the result of the cultivation which has rendered the plant food unavailable.

In the preceding pages the chemical analyses are given of seventy-two surface soils and fifty-two subsoils. An examination of the tables shows wide ranges in the amounts of the different plant-food elements. One soil, for example, contains .07 per cent. of nitrogen, while another contains .68 per cent. The most fertile soils, however, show only limited variations in composition, and if the soils with the extreme percentages are omitted, the arable soils and subsoils of the state show about the following average composition:

TABLE XV. Average Composition of Minnesota Soils.

	Surface Per Cent.	Subsoil Per Cent.
Insoluble matter.....	79.92	82.41
Potash.....	.43	.40
Soda.....	.45	.32
Lime.....	1.29	1.78
Magnesia.....	.61	.80
Iron and alumina.....	7.20	8.32
Phosphoric acid.....	.20	.17
Sulphuric acid.....	.10	.06
Carbonic acid.....	.62	.93
Volatile matter.....	8.98	5.33
Humus.....	3.66	.....
Nitrogen.....	.20	.10

NOTE.—The humus and nitrogen form a part of the volatile matter.

Lime.—A characteristic feature of nearly all of the soils of the state is a large amount of lime in the form of disintegrated limestone. Only a few soils have been found deficient in lime. The average lime content of the seventy-two samples of surface soils reported in this bulletin is 1.29 per cent., and of the fifty-five subsoils, 1.78 per cent. (CaO). Not only is there a large amount of lime, but also a large amount of magnesia. In the surface soils the lime, magnesia, and combined carbonic acid amount to 2.62 per cent., and in the subsoil to 3.51 per cent. This large amount of basic matter takes an important part, both directly and indirectly, in imparting fertility. In many parts of the United States there are large areas of sour or acid soils, caused by a lack of lime, magnesia, or other basic matter. In many of these acid soils there are good stores of phosphoric acid and potash, but because of the acid condition, the plant food is unavailable. The large amount of lime in the soils of this state will, however, prevent the formation of acid soils and the plant food from becoming unavailable.

The amount of lime in the individual soils that have been examined, and the part which it takes in making the plant food available, are discussed in other parts of this bulletin. In the Red River Valley subsoils, 20 to 25 per cent. of lime carbonate was found, while in some of the sandy soils there was less than .20 per cent. A high per cent. of lime has usually been accompanied by a high per cent. of magnesia, suggesting that much of the lime and magnesia are derived from dolomite. In many of the prairie subsoils there is sufficient carbonate of lime to give a light grey color, and cause the soil particles to form hard pound grains which are easily crushed. When treated with acid, nearly all of the soils give an effervescence caused by liberation of the carbon dioxide gas. The high state of fertility of many of our soils is due largely to the lime they contain, which has prevented the formation of humic acid and enabled the remains of former vegetation to form with the soil valuable humates, which our grain crops derive a large share of their food from. Occasionally limited areas are found where the soil could be improved.

by the addition of lime, but the extensive use of lime fertilizers will not be necessary in this state except in these few limited localities. In the numerous "old lake beds" there is a high content of lime, and many of the low lands, which are at present considered waste lands, contain sufficient lime to give them an agricultural value.

This large amount of lime in active form in our soils renders it possible for the farmer to keep the plant food available by means of thorough cultivation, farm manures, and rotation of crops, without the necessity of purchasing commercial fertilizers to supply the necessary food for growing crops.

Potash.—In the 72 surface soils, only 2 were found to contain less than .15 per cent., and 6 less than .20 per cent., while 23 soils contained .50 per cent. or more, the average amount being .43 per cent. The average soil of this state is well supplied with potash. Since an acre of soil to the depth of one foot weighs about 3,200,000 lbs., the potash content would be equivalent to about 13,700 lbs.

In addition to the potash reported in the tables, there is a large amount which is insoluble in the acid used for analysis. This potash, however, cannot be counted upon for crop purposes, because it is in such complex forms; in fact, only a small amount of the 13,700 lbs. can be said to be in actually available forms. A large part of the potash of the soil, particularly of soils of granite origin, is derived from the disintegration of the minerals mica and feldspar. Microscopic examinations show the mica and feldspar in various stages of decomposition. The microscopic particles of feldspar and mica contain potash, not in the free state, but in combination with other elements. In fact, the main store of the soil's potash is present in these soil particles, and when the soil grains are decomposed, the potash is liberated in simpler forms, as the zeolites, which gradually become available. In the presence of manure, this process of decomposition of the potash minerals is hastened by the chemical action of the manure upon the soil. Thorough cultivation also hastens the decay of the soil particles. Farm manures and thorough cultivation are

the two main forces which promote disintegration of the particles, rendering the potash, as well as other plant-food elements, available.

Soda.—In the soils examined, about the same amount of as of potash was found. While the soda takes no direct part in plant nutrition, it is frequently of indirect value, because it is a source of alkaline matter, and aids in maintaining a slightly alkaline condition of the soil which is beneficial; in fact, it is more desirable for a soil to contain .40 per cent. of soda than .20 per cent. because the potash and soda are generally combined in silicate forms, and a fair amount of soda indicates that the silicates are partially disintegrated. The state of decay of the soil particles in a granite soil may be told, to a certain extent, by the content of potash and soda.

Phosphoric Acid.—In only three out of 72 soils was less than .10 per cent. of phosphoric acid. The soils examined showed on an average about 6,400 pounds per acre of phosphoric acid to the depth of one foot. While the total amount is large it is difficult to state the extent to which the 6,400 pounds are available. In the prairie soils a large part of the phosphoric acid, as shown in the preceding article, is combined with the humus or organic compounds in forms available for crops. The humus takes an important part in rendering the phosphoric acid available. Soils deficient in lime and containing .20 per cent. of phosphoric acid, are often deficient in available phosphates, because the alkaline condition of the soil prevents the formation of neutral humus. In the prairie and Red River Valley soils there are large amounts of both lime and phosphoric acid. Soils that have not been continually cropped to small grain also contain large amounts of humus, and in these soils the phosphoric acid is in available forms. A good stock of lime and phosphoric acid renders it possible for the farmer to keep the phosphates of his soil available for crop purposes by using farm manures and rotating the crops so as to conserve the humus. In many soils the phosphates become unavailable because of the destruction of the humus by exclusive grain cultivation.

With the large amounts of lime and phosphoric acid which our soils contain, there will be no necessity for using phosphate manures for general farm crops, because it will be cheaper to cultivate available phosphates than to purchase them. This can be done by keeping up the supply of humus in the soil to combine with the phosphates. Hilgard states that if a virgin soil contains less than .05 per cent. of phosphoric acid there is reason to suspect a poverty of this element. In most of the soils examined three or four times this amount was found.

Nitrogen and Humus.—A close relationship was observed between the amounts of nitrogen and humus of the soil, a high percentage of nitrogen being accompanied by a high percentage of humus. As a rule, there were from 10 to 12 parts of humus to one of nitrogen. Any increase or decrease of humus has been invariably followed by a corresponding increase or decrease of nitrogen. The nitrogen of grain cultivated soils decreases rapidly because when the humus decays the nitrogen is liberated and forms gaseous products, like ammonia, or soluble compounds like nitrates, which are readily lost in the drain waters.

The exclusive cultivation of small grains, particularly wheat, has resulted in the unnecessary loss of large amounts of nitrogen. Many of the rich prairie soils contained originally .4 per cent., or more, of nitrogen,—about a third of a pound of nitrogen in a cubic foot of soil. After 20 or 25 years of grain cultivation the nitrogen has been reduced to about .25 per cent. Only a comparatively small part of the nitrogen has been taken away by the crops, but by far the larger portion has been lost because of the decay of the humus. On some soils this heavy loss has not as yet been felt, because there is such a large amount of nitrogen left in the soil, but on many soils the loss of the nitrogen and humus has been the main cause of the decline in crop yields.

The large amount of lime which our soils contain enables the nitrogen to become available for crop purposes more readily than in the case of soils deficient in lime, since the lime furnishes the necessary basic material for making the nitrogen available. When the nitrogen is combined with the humus it is in a stable form,

but as soon as the humus is destroyed the nitrogen is lost from the soil. The exclusive cultivation of small grains is favorable to the rapid decay of the humus. The grains grown upon the soil are unable to take up all of the nitrogen liberated from the humus, because the fermentation of the humus takes place for nearly seven months during the year, while the wheat crop takes 85 per cent. of its nitrogen from the soil during the first 50 days of growth.

It is not the intention to convey the idea that it is impossible to grow small grains, but it is evident that it is detrimental to the fertility of the soil to continue to raise grain, as it is year after year upon the same land, and in the same way as if a rotation were followed, and the land occasionally manured, both a better yield and a better quality of grain could be secured.

In a former bulletin (No. 53) the influence of crop rotation and farm manures upon the nitrogen content of the soil was considered. Since this subject has such vital bearing upon yields and soil fertility, a few of the main facts observed and reported in the former bulletin are here repeated in the following financial statement with the soil:

PLOT 1. Continuous Wheat Culture.

Nitrogen in soil at beginning of experiment, per cent.....	.....
Nitrogen in soil at close of experiment, per cent.....	.....
Nitrogen removed in crops, lbs. per annum.....	.....
Nitrogen lost from soil in addition to crop, lbs.....	.....

PLOT 2. Rotation of Crops (Wheat, Clover, Wheat, Corn and M

Nitrogen in soil at beginning of experiment, per cent.....	.....
Nitrogen in soil at close of experiment, per cent.....	.....
Nitrogen removed in crops, lbs. per acre.....	.....
Nitrogen, gain to soil above amount removed in crops.....	.....

An increase of five bushels per acre of wheat, and two bushels per acre of corn, was secured by the rotation.

Nitrogen is the only element of the soil that is capable of being increased or decreased without the use of ordinary manure, and since it is the most expensive and one of the most essential elements for plant nutrition, it is important that special attention be given to the soil nitrogen, particularly to its conservation.

stated in former bulletins, it is the main element from which the glutens in wheat and grains are produced, and it is also one of the main elements of chlorophyll, which takes such an important part in the production of plant tissues. Hence it will be seen why this element is important to the plant, and how necessary it is that the soil should contain a good supply, and that every effort be made for its conservation.

Summer Fallowing.—In many cases the loss of nitrogen has been hastened by the extensive practice of summer fallowing, which temporarily increases the yields of succeeding crops, but in the end results in unnecessary loss of nitrogen. Summer fallowing causes the humus to decay rapidly, and in doing so four or five times more nitrogen is liberated than is used by the next crop. Summer fallowing causes an increase in the available nitrogen, but a material decrease in the total nitrogen: Hence, if this practice is continued, the original store of nitrogen will soon be reduced below the point necessary for crop production. If instead of summer fallowing some green crop were grown upon the land and plowed under, as green manure, there would be a new stock of humus added to the soil. Bare summer fallowing should be superseded by green manuring.

In case the land is out of condition, and fails to give good yields of grain, it is preferable to grow a crop of corn upon the land rather than to practice summer fallow. When corn is grown, an increased yield of wheat may be obtained the next year, due to the fact that there is more available nitrogen for the crop; in fact, nearly as large a yield of wheat can be secured after a corn crop as after a year of fallow. For the destruction of weeds and insects, an occasional year of fallow is not objectionable, but alternate wheat and fallow, as practiced on some farms, results in only a temporary increase in yield, at the expense of a future decrease and permanent injury to the soil.

The numerous analyses of soils made during the past few years at this Station have emphasized the fact that if proper means are taken to conserve the nitrogen and humus, there is but little to be feared from the mineral elements as potash or phosphates be-

coming unavailable. The fact that one of our average soils can be extracted for three months with dilute citric acid, and after the acid is removed, and only available nitrogen is returned to the soil, a crop of wheat can be produced, shows that our soils have an unusually large amount of reserve fertility which can be drawn upon for crop production. If the farmer will do her part by keeping up the nitrogen and humus of the soil, nature will do her part, viz., keep the mineral food available. A review of the tables of analyses shows that the high percentages of nitrogen and humus in the long cultivated soils are invariably found where the crops have been rotated, farm manures used, and clover grown.

Reaction of Soils.—The reaction of the soils as acid, alkaline or neutral, was determined by means of moistened litmus paper. Methods have not as yet been perfected for the determination of the *degree* of acidity or alkalinity of soils; hence it is difficult to draw definite conclusions from simply the reaction. The soils tested have given acid, alkaline and neutral reactions. Most of the soils that contain high percentages of humus and organic matter gave slightly acid reactions as well as many that are reasonably well supplied with lime carbonate. A slightly acid reaction does not necessarily imply deficiency of lime, but a strong acid reaction is invariably an indication of lack of lime and active basic matter. Some of the native (uncultivated) soils give slight acid reactions, while similar soils that have been cultivated were neutral. It is believed that the cultivation of the soil and the partial oxidation of some of the organic compounds have been the cause of the change of the reaction of the soils from slightly acid to neutral. Soils which are rich in organic matter must necessarily develop a slight amount of acid before neutralization with the lime can take place; but no perceptible amount of acid can accumulate because of the neutralizing action of lime. A soil that is deficient in lime and gives a decided acid reaction is, as pointed out by Wheeler, at the Rhode Island Experiment Station, in need of some form of basic matter. The soils of this state gave decidedly acid reactions. The slight

ity of some of the native prairie soils containing fair amounts of lime, offers in part, an explanation why clover so frequently fails on new land but will thrive on older land. Clover does not do well when there is a slightly acid condition of the soil. The large amounts of lime and potash in nearly all of the soils of this state are particularly favorable to the growth of this nitrogen restoring crop (clover) and as far as plant food is concerned there is no reason why clover should not be grown on all of the prairie soils. It is to be observed that the clover belt of the state is gradually increasing, and there is every reason to believe that in the few localities where it is thought that clover cannot at the present time be grown the chemical, mechanical, and bacteriological changes which are continually taking place in the soil will gradually prepare the way for this important crop. The condition of the soil as to acidity or alkalinity is an important factor in the determination of the kinds of crops that are capable of being produced. For general agricultural purposes soils which show only a slight degree of acidity or alkalinity are decidedly preferable to those which show either marked alkaline or acid reaction.

Amount of Plant Food in Soils.—Since the draft of crops falls heaviest upon the nitrogen, phosphoric acid and potash of the soil, it is necessary specially to consider these three elements. The analyses show that the soils examined contained on an average 6,400 pounds each of nitrogen and phosphoric acid and 13,700 pounds of potash per acre to the depth of one foot, which are large total amounts of plant food. The relative amounts of plant food elements, compared with the total soil are, however, small. This fact is best observed from the illustration, fig. 7, which gives graphically the composition of the surface and subsoils. The dark part of the volative matter shows the amount of nitrogen in each of the bottles of soil. In 100 pounds of soil there is a fifth of a pound of nitrogen and when it is distributed through the soil it forms only a small amount of the total. In like manner, it will be seen that the potash, No. 6, and the phosphoric acid, No. 7, form only a small part of the soil. The nitrogen, phosphoric acid and potash considered as a whole make less than one

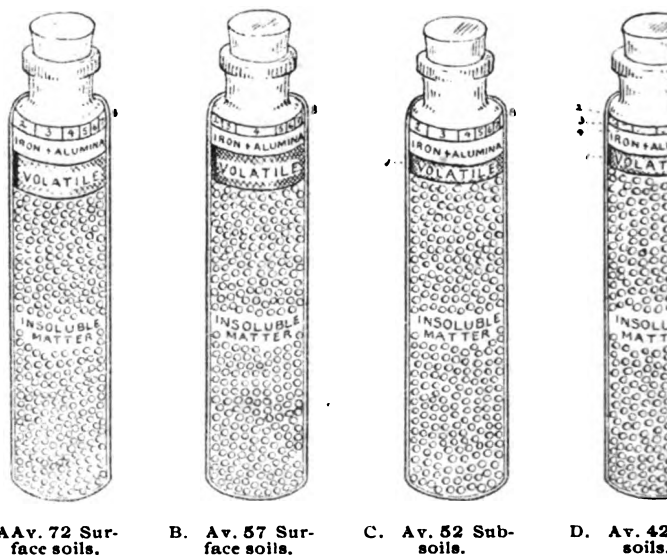


Fig. No. 7. Average composition of soils.

- | | | |
|--|--------------|--------------|
| 1. Nitrogen, (black part of volatile.) | 4. Magnesia. | 7. Phosphor |
| 2. Lime. | 5. Soda. | 8. Sulphuric |
| 3. Combined carbonic acid gas. | 6. Potash. | |

per cent. (.83). The heavy draft of our crops falls upon the parts: No. 1 nitrogen, No. 6 potash, and No. 7 phosphorus. In the case of our most fertile soils it can be said that less than one part of the soil is material that can be used for crops and that 99 parts or more are inert materials which cannot contribute to the growth of a plant. In the soil the plant food is set off by itself as shown in the bottles but the nitrogen, phosphoric acid and potash form a part of each minute soil grain and are diluted by the large amounts of inert matter. The illustrations enable us to understand how it is possible for the plant to be covered up, as it were, by the inactive material in the soil. When it is recalled that crops feed largely upon nitrogen, phosphoric acid and potash which form a relatively small amount of the total soil, the importance of keeping this small amount in the most available forms by thorough cultivation, farm manure, and rotation of crops presents itself in a most emphatic way.

Adaptability of Soils to Variety of Crops.—The mechanical analyses that have been made show that the silt particles form by far the larger portion of the different grades of soil particles. In the prairie subsoils 40 to 60 per cent. is silt,—particles between sand and clay in size. The preference of certain kinds of crops for clay or sandy soils is well known. The silt soils being of an intermediate character and possessing the desirable features and not the objectionable ones of sand and clay are naturally adapted to the production of a great variety of crops. Chemically, the soils are well supplied with plant food, and physically many of them are composed largely of the silt particles. This combination favors the production of a variety of farm crops. In ordinary clay or sandy soil only a limited number of crops can be produced economically, because the physical properties of the soil and the available water supply are favorable to only a few crops. In the case of silt soils with 15 per cent. of clay, a fair amount of lime carbonate, and a good stock of plant food, the most favorable conditions exist for the unrestricted production of general farm crops. Extreme types of sandy and clay soil are found in the state, but in the average soil, silt predominates. Mechanically considered, the silt soils are particularly adapted to a rotation of crops. In fact the fertile silt soils with 15 per cent. clay and a small amount of lime, can by the art of the cultivator be made suitable for the production of almost any farm crop.

Weeds and Fertility.—On many farms weeds have been one of the causes of a decline of fertility. In most of our weeds there are larger amounts of nitrogen, phosphoric acid, and potash than are found in a corresponding weight of grain. When a poor stand of grain and a rank crop of weeds are harvested, the soil is robbed of more fertility than if a heavy crop of grain had been produced. The weeds are harvested with the grain and the weed seeds sold from the farm with the grain, or rather given away as dockage, which results in a loss of fertility from the land. The stronger feeding weeds appropriate the available plant food which belongs to the grain crops. Weeds are also capable of feeding upon cruder forms of food than are the grains, and

when the weeds are harvested along with the crop the s available plant food is reduced. If weeds could be plo der before seeds develop, and left to rot, the fertility wo be lost, and the weeds would be useful in preparing the the more delicate feeding grain crops. With a good sy green manuring this can, in part, be accomplished, a weeds be used as a soil digesting crop.

The fact that some weeds take more fertility from than an average grain crop may be observed from the fo table, which gives the pounds of the three plant food elem ton of material, and also the amount removed in an acre of wheat.

TABLE XVI. Fertility Removed by Wheat and Weeds.

	Nitrogen. Pounds.	Phosphoric Acid. Pounds.	P Po
Wheat, 20 bushels, with straw.....	35	20	
Mustard (entire plant).....	65	26	
Pigeon grass.....	35	20	
Wild barley.....	40	20	
Wild oats.....	30	18	

On some farms the soil is compelled to stand the drain of three competing weed crops, which, with the scant grain cr sults in the loss of a larger amount of total plant food th heavy yield of grain were produced. When weeds take pos of the land, the weaker feeding grain crops are compe compete with the stronger feeding weeds, and the result is val of the stronger. Weeds thrive where wheat would f cause of the difference in the power of assimilating food. may be said to possess strong digestive and assimilative p while wheat and flax possess weak digestive powers; hence are capable of exhausting the fertility of the soil more r than grains

Reserve Fertility of the Soil.—In every soil there are amounts of what may be termed reserve fertility, that is, food which is not in the most available forms, but is capa being made so by cultivation. It should be the aim to kee

reserve fertility in such a condition that it will gradually become available and can be drawn upon by future crops. When the soil is made to produce one crop year after year, there is but little opportunity for the reserve fertility to become available.

The mineral elements of plant food, it should be remembered, are present in, and form a part of the microscopic soil particles shown in figures Nos. 2, 3, and 4. The plant abstracts its food from these soil particles, and the less decomposed they are, the more difficult it is for the plant to obtain its food. If proper means are taken, it is possible to have some mineral food in all the different stages of decomposition, so that as soon as the most available is taken up by the crop there are other forms ready to be acted upon and made available to take the place of that which has been removed.

The farmer in preparing food for his crops should look upon the problem in the same way as does the housewife in her preparation of her daily food. The available supply may be said to be that which is on the table and ready to be consumed. The reserve supply is that which is in the unprepared forms of flour, sugar, meat, etc. It would be considered very poor management to allow the reserve supply to become exhausted and take no measures for its replenishment. So with plant food. Nature has prepared a generous supply in available forms, but unfortunately the cultivator of the soil does not always use the proper means to keep up the reserve store to take the place of that which nature has supplied, and the result is a decline in the yield of crops. If, however, the reserve supply is kept up and is called into use, no decline takes place. The farmer should prepare the reserve plant food in the soil so that it can gradually be brought into use when needed, in the same way that the housewife holds in reserve flour, sugar and meat.

When it is more generally understood that plants as well as animals need food and that it is possible to assist nature in preparing this food, the necessity of keeping up a good working supply both available and reserved will be more fully recognized.

What is this reserve plant food, and how can it be kept

available? It is the plant food which is in process of becoming available, and the process can be hastened by the use of farm manures, rotation of crops, and thorough cultivation. That farm manures aid in making plant food available has been demonstrated in former bulletins. The action of the vegetable matter upon the soil particles is also shown by the microscopic examination of the surface and subsoils. The surface soil particles in the presence of ordinary amounts of vegetable matter are different in character from the same kinds of particles in the soil which is comparatively free from organic matter. In the presence of the vegetable matter the surfaces of the soil particles are more roughened and appear as if they had been acted upon by some solvent or eaten into. This roughening of the surfaces of the particles is due to the action of the vegetable matter, and

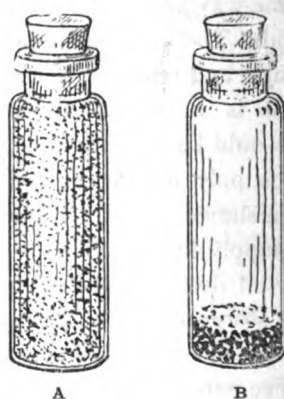


Fig. No. 8. A, Native prairie soil. B, Humus materials extracted from soil A.

doubtedly by micro-organisms. The mineral plant food elements which have been detached from the surfaces of the soil particles or microscopic stones, and combined with the vegetable matter, form the reserve and finally the available plant food of the soil.

Importance of Crop Rotations, and the Use of Farm Manures.
A brief review of the facts presented in this bulletin and ob-

as the result of the chemical and mechanical analysis of the soils of this state, the study of the available plant food, and the action of the organic matter upon the soil particles, emphasize the importance of the systematic rotation of crops, the judicious use of farm manures, and the thorough cultivation of the land as the proper means for conserving the fertility of the soil. It is evident that if these measures are taken in time the decline in the yields per acre of wheat and small grains can be prevented. The wheat crop is not necessarily "hard on the land;" an average wheat crop, as shown in bulletins Nos. 29 and 47 of this station does not remove from the soil any more fertility than a corn or a heavy grass crop. When wheat or a small grain crop is grown exclusively the decline in the yield which invariably results is due, not so much to the fertility that is removed, as to the effect which the crop and the method of cultivation have upon the soil. The uncovered condition in which wheat lands are left for nearly eight months in the year is the cause of the heavy loss of fertility. It is unnatural for a soil to be continually under the plow, no new vegetable matter is added to the land, and a rapid decline of the soils original stock occurs. The fact that weeds grow so vigorously when the one crop system is followed is a sign that nature protests against such a practice.

When the large amounts of plant food, the lime content, the balanced condition and the unique chemical composition and mechanical structure of our prairie soils are considered, and then the fact that less than twelve bushels of wheat per acre are obtained from some of these "old wheat lands," it is evident they are not producing the crops that nature intended. How can these old wheat lands be made more productive? Various ways have been proposed, as summer fallowing, and the use of commercial fertilizers. Summer fallowing, as shown on preceding pages is temporarily beneficial, but when practiced only puts off the trouble and makes it more serious to deal with in the future. The use of commercial fertilizers has been suggested. It is doubtful if fertilizers costing \$35 to \$50 or more per ton can be used economically on prairie soils for the production of wheat, since a heavy

application of the fertilizer would in many cases exceed the market value of the land. If used, weeds as well as crop would be fertilized and the weeds would certainly get their share. The use of commercial fertilizers is advisable only where intensified farming is followed. In fact, neither summer fallowing nor commercial fertilizers can be relied upon to solve the problem.

The only rational way to make old wheat lands more productive is to rotate the crops, use farm manures and practice more thorough cultivation. When crops are judiciously rotated, excessive losses of nitrogen and humus are prevented, and the evils of a one-crop system avoided. The use of farm manures and the thorough cultivation of the land aid in making the reserve plant food available. In the cultivation of the land the farmer should endeavor to assist nature in making plant food available and not attempt to work against her.

Every factor in nature seems to have been at work to make prairie soils fertile. They have been formed from a variety of the best kinds of soil producing rocks and minerals which have been pulverized and distributed by glacial action, and enriched by the natural workings of animal and vegetable life. It is the duty of every cultivator of the soil to assist nature in the preservation of the fertility of the soil.

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Agricultural Experiment Station.

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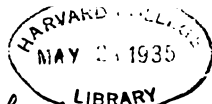
ENTOMOLOGICAL DIVISION.

DECEMBER, 1899.

BEETLES
INJURIOUS TO FRUIT-PRODUCING PLANTS.

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BEETLES

(*Coleoptera*)

INJURIOUS TO OUR FRUIT-PRODUCING PLANTS.

This extensive Order of insects embraces over 80,000 different kinds of beetles, of which over 11,000 species are found in North America north of Mexico. A very large number of destructive beings is placed in this order. They are not alone injurious to the foliage and fruit, but also to the very trunks and roots of trees. Some of them exist freely exposed in all their stages, while many more live hidden in infested plants, in fruit, in seeds, and in the soil near by. Notwithstanding the various forms at home in all conceivable places, they are readily recognized as beetles, and only a very few rare species may give the farmer trouble in placing them in the Order to which they belong. In a few words the following definition will describe all kinds of beetles: *they possess a pair of horny wing-covers called elytra, which meet on the back in a straight line, i. e., do not overlap, and beneath these horny organs are the true wings, composed of more or less delicate membranes. The mouth-parts are formed for biting, not for sucking. The metamorphosis is complete, or, in other words, the different stages do not resemble each other, and the pupa is inactive, neither moving about nor taking food.*

Any insect possessing the above characteristics is a beetle, and in Minnesota there need be no difficulty in recognizing it as such. The scientific term *Coleoptera* is derived from two Greek words: *coleos*, a *sheath*, and *pteron*, a *wing*. This name characterizes these insects very well, as the horny and sheath-like elytra or wing-covers protect the delicate true wings below. Sometimes these elytra cover the whole upper part of the abdomen as well. Although they occupy the position of the fore-wings, they are, perhaps, not true wings at all, as in all events they are not used for flight. The hind-wings are membranous and excellent organs for flight, being mostly very large, with few but strong supporting veins. When not in use these wings are snugly folded be-

neath the horny wing-covers. To enable the beetle to fold large organs beneath the very much smaller elytra they are only folded lengthwise like a fan, but also crosswise, which is made possible by a sort of hinge or joint beyond their middle. The structure of both elytra and true wings can be best studied

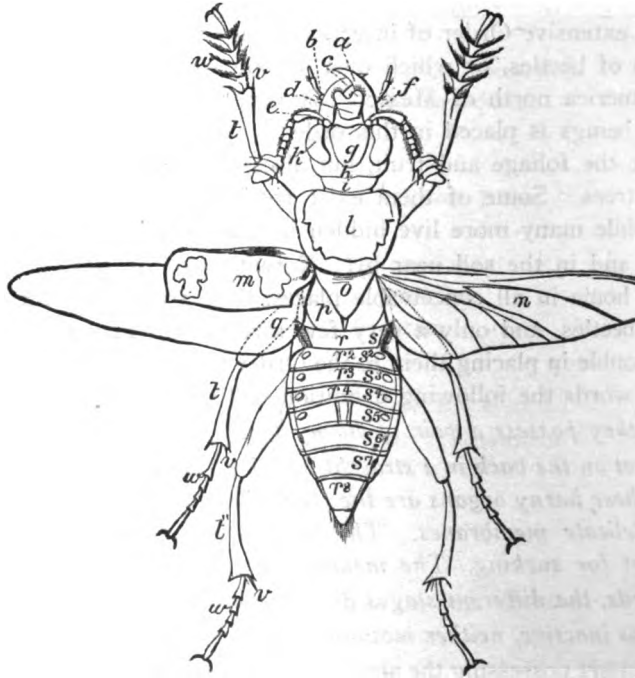


Fig. 1.—Upper surface of *Necrophorus americanus*: a, mandible; b, palpus; c, labrum; d, clypeus; e, antennae; f, front; g, vertex; h, occiput; i, eye; j, pronotum (usually called prothorax); k, scutellum of meso-thorax; l, pronotum; m, elytron; n, true wing; o, scutellum of meso-thorax; p, metanotum (or dorsal surface of metanotum); q, femur or thigh; r, r, r, tergites of the abdomen; s, s², s³, spiracles or spiracles; t, t', t'', tibiae; v, tibial spurs; w, tarsi. After Leconte.

dissecting some common large beetle. Fig. 1 shows the upper surface of a *Necrophorus americanus*; Fig. 2 shows the same in a Tiger-beetle (*Cicindela*).

There are a number of beetles that do not fly, and, according to the natural law that organs not used become rudimentary, the lower or true wings have dwindled to

nothing, or have disappeared entirely. In many cases of this kind we find that the wing-covers do not simply meet on the back, but that they are actually soldered together, so that the elytra form one solid piece; the suture can, however, readily be detected. (Compare illustrations 180 and 181).

The exposed parts of the body of most beetles are very hard and horny. This is at least the case with all such as lead an active life, and is very necessary to their very existence, not only as a protection, but also because the muscles enabling them to run or fly have to be fastened to this exterior skeleton. Less active

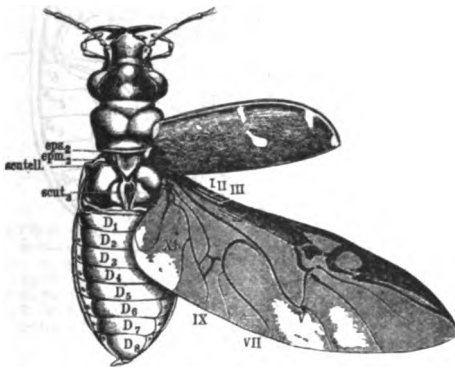


Fig. 8.—Upper surface of *Cicindela*: *epm*², episternum of meso-thorax; *epm* epimeron of meso-thorax; *scutell.*, scutellum; *scut.*², scutum of meta-thorax; *D* — *D*⁸, dorsal segments of abdomen; *I*, vena marginalis; *II*, vena mediana; *III*, vena scapularis; *V*, vena externo-media; *VII*, vena cubitalis; *IX*, vena interno-media; *XI*, vena analis. After Ganglbauer.

beetles, and all others in their earlier stages, in case they are not forced to search for their food or when surrounded by some protecting material, as soil, wood, or fruits, are usually softer; their outer covering, which is composed of chitine, a horn-like substance, is in such cases soft, frequently very much so. Such a pliable skin is very important in the early stage of a beetle, as it enables the larva to stretch during its rapid growth, and to form the organs of the adult insect while changing to a pupa.

The biting mouth-parts are well developed in all *true beetles*, and we do not find some of them enlarged at the expense of others, as in the case of butterflies and moths. The upper lip or

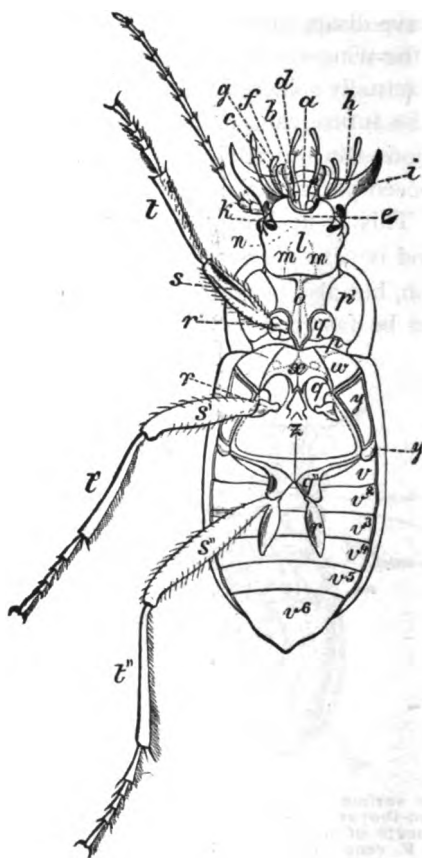


Fig. 2.—Under surface of *Harpalus caliginos*: a, ligula; b, paraglossa; c, porta of labial palpi; d, labial palpus; e, mentum; f, inner lobe of maxilla; g, lobe of maxilla; h, maxillary palpus; i, mandible; k, buccal opening; l, throat; m, m, buccal sutures; n, gular suture; o, pro-sternum; p', episternum of pro-thorax; p, epimeron of pro-thorax; q, q', q'', coxæ; r, r', r'', trochanters; s, s', s'', femora or thighs; t, t', t'', tibias; v, v', v'', etc., ventral abdominal segments; w, episterna of meso-thorax (the epimeron is just behind it); x, sternum; y, episternum of meta-thorax; z, epimeron of meta-thorax; etc. After Leconte.

labrum is usually distinct; the *mandibles* are strong jaws which can be used for gnawing and for seizing the prey; the *commaxillae* are also well developed and are composed of several pieces; the *maxillary palpi* are usually prominent; the lower *labium* is composed of several pieces, and bears prominent *palpi*. All these parts are shown in Figs. 2, 4, 5 and 7.



Fig. 4.—Under surface of male *Cicindela*: *a*, antenna or feeler; *lbr*, anterior margin of labrum; *md*, mandible; *mx*, maxilla; *p. mx*, maxillary palpus; *m*, mentum; *p. l.*, labial palpus; *s. g.*, gular suture; *st*, prosteronum; *st*², mesosternum; *st*³, metasternum; *eps*¹, *eps*², *eps*³, episterna of pro-, meso- and meta-thorax; *epm*¹, *epm*², epimera of pro- and meso-thorax; *v-v*⁷, ventral segments of forceps; *c*¹, *c*², *c*³, coxae; *tr*¹, *tr*², *tr*³, trochanters; *f*¹, *f*², *f*³, femora; *tib*¹, *tib*², *tib*³, tibiae; *t*¹, *t*², *t*³, tarsi. After Ganglbauer.

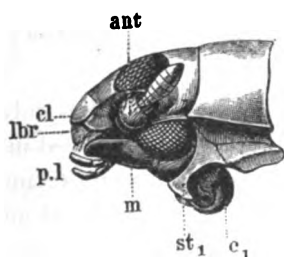


Fig. 7.—Head and thorax of *Gyrinus* from the side: *ant*, antennæ or feeler; *cl*, clypeus; *lbr*, labrum; *p. l.*, labial palpi; *m*, mandible; *st*, prosteronum; *c*, coxa of front leg; each compound eye is divided into two parts, one above the antennæ and one below. After Ganglbauer.

The *Snout-beetles*, which form the suborder *Rhynchophora* of the order *Coleoptera*, have the head more or less prolonged into a snout or beak called the *rostrum*, which is in some cases longer

than the rest of the body. Such beaks, as may be seen in figures illustrating snout-beetles, vary greatly, being sometimes broad and short, long and thin, or straight or curved. At the very tip of this beak we find the sharp jaws, at least with

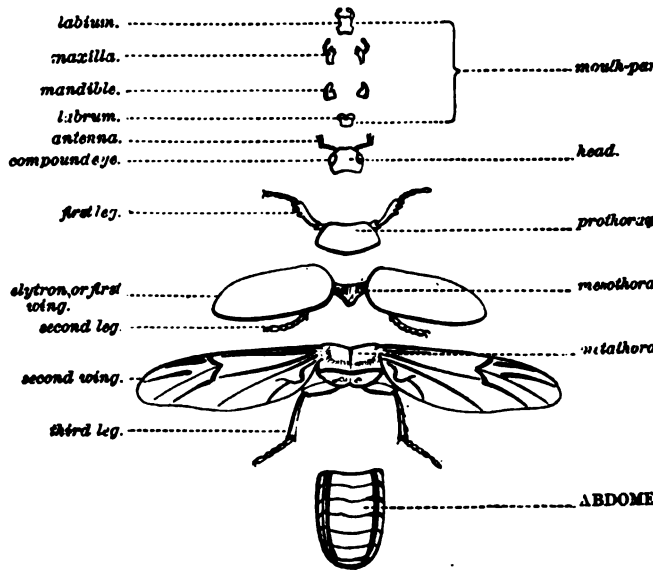


Fig. 5.—Division of body; separated to show parts.

adult insect is still very young and has only shortly left the egg. The slender feelers or *antennae*, elbowed in the middle, arise from the sides of the beak, and frequently fit into grooves, so as to be well protected when the beak is inserted into food.

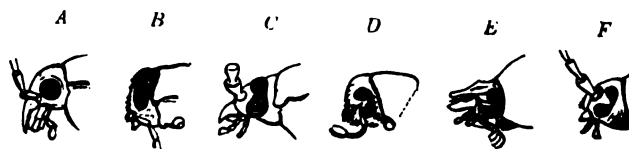


Fig. 6.—Eyes of beetles: A, of *Calosoma*; B, of *Chrysobothris*; C, of *Tomicus*; D, of *Geotrupes*; E, of *Tetroplum*; F, of *Tetroplum*.

The compound eyes (Fig. 6) of most beetles are prominent, and are of various forms: round, oblong, kidney-shaped, curved, or in one case even divided in the middle, thus giving the impression that the insect possesses four instead of two eyes (Fig. 7). Each eye is composed of many six-sided facets, varying in number from a few to many hundreds. Some beetles found in caves have



Fig. 8.—Serrate Antennæ and modifications: 1, serrate; 2, pectinate; 3, bipectinate; 4, flabellate; 5, plumose; 6, 7, 8, irregularly serrate, approaching the Clavicorn type. After Leconte and Horn.

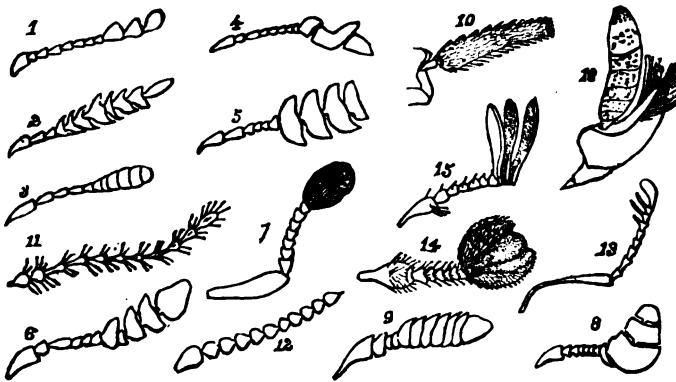


Fig. 9.—Clavate Antennæ, 1-10; Capillary and Verticillate, 11; Moniliform, 12; Lamellate, 13-15; Irregular, 16. After Leconte and Horn.

no eyes at all. *Ocelli*, or single eyes, do not often occur, though some beetles have two or even only one *ocellus*. The compound eyes of snout-beetles are usually small and round.

The feelers or antennæ of beetles possess various forms, some of which are exceedingly singular and beautiful, resembling feathers. A number of such feelers are shown in Figs. 8 and 9. To

give space to the numerous sense-organs located in them. The feelers, usually composed of eleven joints, are either lengthened very much, are feather-like, or are like the leaves in a fan. In this manner the entire surface is greatly enlarged. The base of the feeler serves to a great extent as a basis for classification, hence its different shapes have received special names, and can be seen by consulting the illustrations.

Like other insects, beetles possess a thorax composed of three pieces, closely soldered together (Fig. 5). In most insects the face of all three pieces can be seen from above; in beetles, however, only the anterior piece, the usually broad pro-thorax, is visible on the back. The two other pieces are hidden below it. In the exception of a small wedge-shaped piece, a section of the middle thorax, which is termed the *scutellum*. This is, in most beetles, plainly visible where the sutures of the elytra join near the anterior margin of the pro-thorax. A study of the illustrations will explain the anatomy better than a mere description. The head joins the thorax by a wide base; the former is in many beetles entirely hidden and protected by the wing-covers, hence soft. But whenever these wing-covers are short, the face of the abdomen not covered by them is hard and heavy. The back always is on the unprotected lower surface. When not covered, the abdomen is not only soft, but also light in color; all the other parts are darker, and frequently beautified with marking of various colors and patterns.

Besides the wings already mentioned the adult beetle possesses as organs of locomotion six legs, which vary greatly in shape, as may be seen in Fig. 10. Beetles which live in water are adapted for swimming; those that have to run quickly in search of other insects possess very long legs to enable them to catch their prey. Others again, which live upon plants, have their legs arranged to hold on as tightly as possible, so as not to be blown down by even a heavy wind, and still others, which live on the ground, have at least their front legs so arranged that they can burrow with great ease. In fact, by looking at the legs of a beetle the observer can soon judge what the habits of the beetle are. In most cases the legs are the principal organs of locomotion, and only in a limited number of beetles are both

ings used with equal facility. At all events it is with but few exceptions easier for a beetle to run than to fly, simply because, in preparing to fly, it is forced first to lift the wing-covers out of the way to permit the folded true wings to come into action. Whoever has watched a June-bug, which, attracted to the light, had hopped upon a smooth table, and has seen it try to escape by flight, has also noticed how awkward it is, and that it has first to crawl upon some elevated object to be able to unfold the true wings at all. First the heavy wing-covers are lifted right over the head, then the true wings are unfolded, and after a sort of pumping mo-



Fig. 10.—*Natatorial Legs*, 1-2; *Fossorial*, 3. *Tibiae*: unguiculate, 4; mucro, 5; closed corbels, 6; open corbels, 7. *Tarsi*: lobed beneath, 8; lobed and with onychium, 9. *Claws or Ungues*: pectinate, 10; serrate, 11; toothed, 12; cleft and serrulate, 13; cleft, with equal movable parts, 14; unequally cleft, 15; also also toothed, 16; cleft and divaricate, 17; connate at base, 18; with membranous appendages, 19; chelate, 20. After Leconte and Horn.

on the beetle eventually flies away, perhaps against the lamp to repeat the ludicrous performance over and over again. The legs of adult beetles are horny, and usually very strong. Each is composed, as may be seen in the illustrations, of a number of joints, e. g. the *coxa*, *trochanter*, *femora*, *tibia* and *tarsus*. The number of joints in the tarsus or toes—if we can call such organs arranged lengthwise by such a name—varies from three to five, the last one terminating in most cases in a pair of sharp claws. The classification of beetles depends largely upon the number of such toes, which are, however, not always easily seen. In some cases the terminal two are soldered together, or the last one is sunk in the one above it, and sometimes it requires close study to detect the real number of these useful organs. The lower surface of some

or of all the tarsi, is clothed with small *pulvilli*, looking which are used almost like sucking disks to enable it to adhere to smooth surfaces.

The beetles undergo a complete metamorphosis. usually soft, white or colored, are deposited by the mother or near the food required by the young. These eggs hatch into larvæ, which are commonly called "grubs," as, for example, the well-known "white grub." Other larvæ are covered with a thick integument, as the young of our common click-beetle known by the name "wire-worms." Most of the larvæ are clumsy looking objects, with darker and horny heads, and pairs of rather awkward looking, sprawling legs on the segments of the body, the *thoracic segments*. No *false* legs have them in the caterpillars of the butterflies and moths, but in many cases there is a sort of *pro-leg* on the first segment of the body. The name pro-leg is rather poorly chosen, for the organ found in such a position. Sometimes the larvæ have one or two rows of fleshy projections or tubercles along the sides, or on the upper or under surface, by means of which they move in tunnels in the ground or elsewhere.

The larvæ of aquatic beetles possess numerous gills along their sides, which assist them in swimming. As to all larvæ of beetles which live enclosed in wood or in the ground, which they feed, have no legs at all, simply because they are rounded by plenty, they have no use for them. As to the larvæ of beetles which have to be active in searching for food, which have to cling tenaciously to food obtained, whether it consists of leaves or living insects, have longer and stronger legs adapted for such purposes. As all growth of a beetle takes place during the larval stage, the larvæ have to eat much, hence are always hungry. They have to take food not simply to grow, but also to store up material for the future organs possessed by the adults alone, and not found in the larvæ themselves. The larvæ have to throw off their old skin from time to time to enable them to reach their full size, since their skins can not grow with them. The number of such changes or molts, the greedy grub has to undergo to reach its full size, and is then filled with a large amount of food material, a store of surplus food. It now changes to a pupa.

change takes place in many ways, which will be mentioned later, when describing the different noxious insects.

The pupa can no longer move about, but is helpless, and does not take any food. In this condition it already shows all the external organs of the future beetle, but all of them are still enclosed or encased in separate sheaths. Such a pupa is called an *obtect* pupa. While apparently quite inactive, wonderful changes are being silently wrought, and all the stored-up food is being utilized for this purpose. At last the pale, almost white pupa becomes darker and darker, and the colors of the future beetle commence to show themselves through the semi-transparent pupal skin, which eventually ruptures, and a weak beetle with wings still small appears. The wings soon harden, the other members stretch themselves to their full length, and the adult can now enjoy life and liberty. At first quite weak and pale, it soon becomes strong enough to eat, court, mate, and die.

As a general rule beetles remain in the egg-stage but for a few days; as larvæ they eat and grow from a few weeks to several years. The pupal stage also generally lasts but a short time; the adults in most cases are short-lived, but others hibernate as perfect beetles.

Beetles and their larvæ feed upon all kinds of vegetable and animal substances; some may eat parts of the rarest flowers, others enjoy the rank-smelling carrion; some eat fruits of all kinds, and even the most pungent spices do not escape their hungry jaws. Still others are decided cannibals and eat other insects. Notwithstanding their immense numbers, the order as a whole is not very destructive, at least not in a state of nature. As a general rule the wood-boring kinds prefer sickly or dying trees and thus they act as scavengers, and by removing the dead material make room for new growth. Many, if not most insects of this order, feed upon plants that are of no use to man, and they even injure or destroy weeds, hence can become our friends. But those kinds that devote their attention to eating plants we grow for our own use, or which destroy useful timber or manufactured goods, or which invade our houses to eat material we wish to use ourselves, all these are our enemies, and have to be treated as such. Especially is the grower of fruit greatly troubled by such insects,

and it will be the aim of the following pages to describe the various kinds, illustrate them, tell about their life-histories, and the most approved methods for killing them or for preventing their ravages in other ways.

The beetles discussed in these pages are all, or nearly all, either directly injurious or beneficial. They are arranged according to their food-plants, but according to the classification of beetles, so that those interested in such matters may also find something of interest to them.

As far as a classification of beetles is concerned, it would of course be impossible to give one that would include all the beetles found in the United States, or even those occurring in Minnesota alone. Nor is it the office of the entomologist to give in these pages, his main object being to describe beetles injurious to fruit-producing plants, and to give the proper remedies against them. For this purpose no attempt will be made to give a description of all the families that compose the Order of Coleoptera, and the reader will understand the reason when he finds that the beetles of North America, exclusive of Mexico, are arranged in about eighty distinct families, representing upward of seventeen hundred genera.

Our recognized authorities in this order of insects make the following primary divisions:

BEETLES.

(Order *Coleoptera*).

I. *Coleoptera* (Typical or True Beetles), in which the normal parts are all present, and in which the front of the head is elongated into a beak or rostrum.

1. *Isomera* (Similar joints). The beetles contained in this division have, with rare exceptions, the same number of tarsi in all their feet.

A. *Adephaga* (Carnivorous beetles). These beetles possess thread-like feelers with distinct and

dricol joints. Here belong the Tiger-beetles, Ground-beetles, Carnivorous Water-beetles, Whirligigs.

B. *Clavicornia* (Club-horns). These beetles have the feelers thickened gradually or abruptly toward the tip. Here belong the Burying-beetles, Rove-beetles, Lady-bugs, Carpet-beetles.

C. *Serricornia* (Saw-horns). These beetles have the feelers toothed or serrated. Here belong the Snapping or Click-beetles, the Saw-horned Borers, the Fire-flies, the Soldier-beetles.

D. *Lamellicornia* (Leaf-horns). These beetles have the knob of the feelers composed of several leaf-like or blade-like parts, which can be closed together at will. Here belong the Stag-beetles, "Tumble-dungs," May-beetles, Flower-chafers, Rhinoceros-beetles.

E. *Phytophaga* (Plant-eaters). Most of these beetles possess thread-like feelers, which are frequently very long, or shorter and slightly thickened towards the tip. The fourth and fifth joints of the tarsi are consolidated, and the former is minute, and sometimes difficult to detect. Here belong the Long-horned Borers, the Leaf-feeding beetles, the Seed-beetles.

2. *Heteromera* (Different joints). The beetles contained in this division have five-jointed tarsi in each of the front and middle legs, and only four in each of the last pair.

This section requires no division into tribes. Here belong Oil-, Blister-, and Meal-beetles.

II. *Rhynchophora* (Snout-beetles), in which the front part of the head is more or less drawn out into a beak or rostrum; the labrum is not distinguishable, and the palpi are reduced to minute points without joints.

In this sub order belong a number of families, some containing but a very few genera or even species. Here belong the Broad-snouted beetles, the True Snout beetles, such as the Nut-weevils, the Rice and "Bill-bugs," the Leaf-rollers, and the Bark-beetles.

COLEOPTERA (TRUE BEETLES).

Among the true beetles we possess a large number of friends and, as it is just as important to know our friends as to know our foes, so as to protect the former and combat the latter, a description of them should find a place in these pages.

I. ISOMERA. (*Similar joints*).

A. CARNIVOROUS BEETLES.

(*Adephaga*).

Beetles of this group are numerous, and a number of species will be described and illustrated. Most of these insects feed upon others, and destroy large numbers of plant-eating insects. A few of them have, however, a mixed diet, and also eat the pollen of flowers, seeds of grasses, grains still in the milky stage, and similar substances. Such exceptional beetles can usually be recognized by their form, which is quite stout and heavy, in fact they must have more space in their stomach, and must have longer intestines to accommodate such bulky food than beetles that live on the concentrated food obtained by eating other insects. But the former also eat insects, when not as adults but do so as larvæ; hence they are friends, though they are not so beneficial as those having a strictly animal diet. A number of families belong to the Carnivorous beetles.

FAMILY TIGER-BEETLES.

(*Cicindelidæ*).

These are most active beetles, which use wings and legs with equal rapidity and facility. They are active only during the sunny and warm portions of the day, and are so swift in all their motions, either in flight or running, that they are not readily taken. During the night, and also during dark and rainy days, they

under loose pieces of bark and flat stones, or burrow in the sand, sometimes to a depth of four or five inches. A few species are strictly nocturnal, but some others are found running about in the sun during the day and may also be attracted to lights at night.

As a general rule tiger-beetles prefer sandy spots or sandy roads, over which they run very swiftly, and as their senses are very alert, they discover approaching persons very soon, and escape molestation by running or flying away. But they run or fly but a short distance, never leaving the sandy spots, so that the eyes of the observer can follow their motions, and he can approach closer by taking the proper precautions. Their alertness is shown by the fact that when settling again after a short flight they almost invariably face the intruder. They are of medium

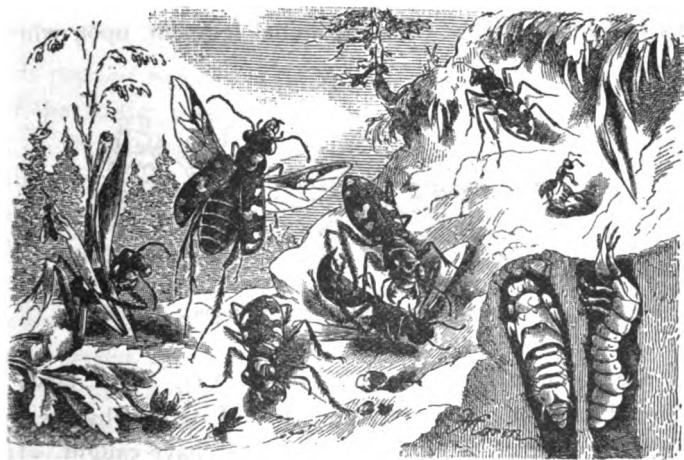


Fig. 11.—Tiger-beetles, all stages. Enlarged. After Brehm.

size, frequently less than three-fourths of an inch long, and possess brilliant metallic colors. Their wing-covers are usually spotted with white. Their popular name, "Tiger-beetles," is a well-chosen one; they are veritable tigers on account of their ferocious habits, their swift movements, the markings on the elytra, and the stealthy manner in which their larvæ lie in wait for insects.

The illustrations (Figs. 3 and 4) give both upper and under face of one of these beetles, dissected in part to show the d. Fig. 11 shows the earlier stages of this beetle. The larvæ of tiger-beetles are as ugly as the mature insects are beautiful. They live in vertical holes in the ground, usually in places similar to those in which the adults display themselves. Such burrows are often a foot or more deep, and are not infrequently found in sunny spots in an orchard. Such larvæ, with large and dirty-colored heads and equipped with immense jaws and long sprawling legs, usually watch at the mouths of their burrows for any approaching insect, and they are always ready to seize it as it walks over such living traps, hidden by the watchful grass which almost entirely fill the entrances with their formidable bristles. In addition to its six legs the larva possesses another pair of appendages, which assists it in climbing up and down in its burrow. This is a hump on the fifth abdominal segment, upon which



Fig. 12.—Tiger-beetle, adult, larva and pupa. After Brehm.

two hooks curving backwards (Fig. 12). The larva, when anchored can not readily be drawn out of its trap by the exertions even of large caterpillars that it may have caught. If a caterpillar is dragged into the burrow and is caught at its leisure. When we thrust a straw into one of these traps, and then dig it out with a spade or trowel, we usually find the vicious hermit at the lower end of the burrow, biting savagely at the straw. Sometimes by introducing a straw we can even force the vicious larva to the surface, since it is so tenaciously fast to it that it will act like a bulldog tearing at the throat of another dog. By singing into the holes the larvæ are sometimes induced

come to the entrance of the pit, not to listen to the sweet sounds produced by the inquisitive boy, but to capture the imaginary intruder. The pupa is also found in such burrows; it is of the usual form, foreshadowing the future insect.

Tiger-beetles, and especially their larvæ, are sometimes very beneficial to owners of fruit-producing plants. The writer has in one instance counted nearly a hundred such burrows in the vicinity of a single large and isolated apple-tree, and many fat caterpillars were devoured by the always hungry trap-dwellers. Of course much of the food consumed consists of insects habitually running over the ground.

FAMILY GROUND-BEETLES.

(*Carabidae*).

This popular name is in the majority of cases a good one, as most of the beetles belonging to this family are found upon the surface of the ground in their adult stage. It is a large family, containing, in the United States, about 1,200 species. Yet, notwithstanding this large number, they are not seen as often as might be expected, simply because the great majority of them are nocturnal in their habits. This accounts for their dark color. Others, however, are very brightly colored, some are metallic, some blue, green, or almost white, the color depending on the general color of the surroundings. By this is not meant that the insects have the power of changing their color, like a tree-toad, but that they are only found in such places as blend with their colors.

Some of these predacious beetles may occasionally be seen running over the ground in gardens, orchards, and in fields, or they may be seen even in the trees themselves, searching for food. But most of them hide during the day under stones, boards, or dead leaves, and they do not leave these shelters until night. Like the tiger-beetles, the ground-beetles possess thread-like feelers, which taper gradually towards the tip, and are composed of

joints which are nearly uniform in thickness throughout length. The legs, with but few exceptions, are adapted for running, which some of them do with amazing rapidity. In the senses of these beetles are very acute. Ground-beetles are distinguished at a glance from the tiger-beetles by having their prothorax narrower than the pro-thorax. They depend more upon their legs for locomotion than upon their wings, and but very few fly. Some have lost their true wings almost entirely, and in such cases the elytra are soldered together at the surface on the back.



Fig. 15.—*Calosoma frigidum*. Kirby.
Original.



Fig. 13.—*Calosoma calidum*,
a larva of another species.

The larvæ (Fig. 13) are mostly long, flattened grubs with a body of almost equal breadth throughout. The larvæ are usually protected on top with horny plates, and ends in a pair of conical and bristly appendages. Most of the larvæ live in the same obscure situations in which the adults live, and they burrow just beneath the surface of the earth. Here they destroy large numbers of the soft leaf-feeding insects, and have entered the ground for transformation. Like the adults they are predacious. Others may, perhaps, also feed on some vegetable food like the adults, but they cause no loss of any great economic importance. When fully grown they transform to pupæ under ground, where they have formed cells for this purpose. Soon afterwards the pupæ change from almost white to the distinguishing colors of the adults, and

ing the old pupal skin behind, the young beetles reach the surface.

Among the most useful of the ground-beetles several deserve special mention, since they help us greatly to reduce certain injurious insects. The Caterpillar-hunter, (*Calosoma scrutator* Fab.), is one of them. It is one of our largest and most beautiful ground-beetles, having metallic green wing-covers, margined with reddish; the rest of the body is marked with violet, blue, gold, green, and copper. It is shown in Fig. 14.

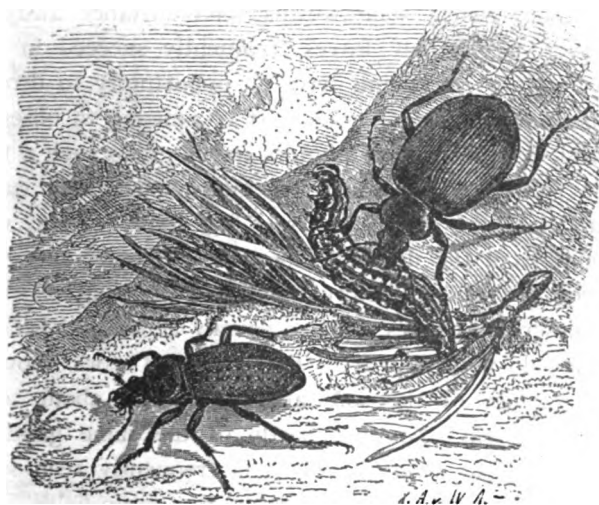


Fig. 14.—*Calosoma*, similar to *C. scrutator*, Fab., below a *Carabus*. After Brehm.

This insect ascends trees in search of caterpillars, and wherever the tent-caterpillars, frequently so destructive in Minnesota, are found in large numbers, the beetles will make war upon them; but few other insects care to attack and eat such hairy worms. It is a pleasure to a person interested in the well-being of his trees to watch this beautifully armored warrior catch a caterpillar, and holding the squirming object in its powerful jaws, suck out its life-blood. The empty skin of the victim is dropped, and another unlucky worm is caught and treated in the same man-

ner. The appetite of the beetles is truly without limit, and they eat all day if they have an opportunity to do so. It is to be noted that they are not more numerous in all our orchards and fields in the north; they are confined to the more southern part of the state.

Another species of caterpillar-hunters, (*C. frigidum* K.), is, however, very numerous in the northern part of Minnesota. It climbs trees as well as the one described, but it is of a different color, (Fig. 15). Wherever canker-worms abound large numbers of these beetles congregate, and they climb trees in search of them. They detect such worms some distance away and rushing over twigs and leaves, frequently succeed in catching them before their victims have an opportunity to drop or hang suspended by silken threads. It is amusing to observe the unsuccessful, how the baffled hunters try to grasp such a caterpillar with their front feet in which not infrequently they succeed. Others are stationed below the tree, and many of the worms that descend from the defoliated branches to enter the ground for pupation are caught before doing so. The larvæ of the above described beetles are also equally active and beneficial. Though they do not climb trees they do good work above and below the surface of the soil, always hunting about to find some insects to eat. Another beetle of the same genus, the "Fiery Hunter" (*C. calidum* Fab.), is frequently seen searching for cut-worms and other food in the grain-fields in the open prairies. It is readily recognized by its black wing-covers with rows of reddish or copper-colored pits. It is illustrated in Fig 13, with its larva.

When we turn over loose stones and boards lying about the edges of fields and orchards, we frequently discover many large black beetles having thorax and wing-covers bordered with blue. They seem to be very slow in their actions, and do not usually attempt to escape. But not everyone likes to pick them up with the fingers, as they have a sort of dangerous look about them, possessing very formidable jaws. These insects are very useful, and locust-infested fields contain them in large

bers. The writer has counted a great many hundreds in a small space in a ditch adjoining a field invaded by the army-worms. Here they were resting from the night's labor of eating such worms.

Fig. 16 shows one of the largest kind, the Western *Pasimachus californicus* Chd., and Fig. 17 a related smaller species, entirely black, the *Clivina impressifrons* Lec.

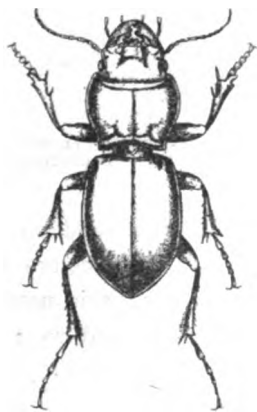


Fig. 16.—*Pasimachus californicus*, Chd. After Leconte.



Fig. 17.—*Clivina impressifrons*, Lec. Enlarged. After Forbes.

To the carnivorous beetles belong also the "Bombarding-beetles," (*Brachinus* species), which have a red head, thorax and legs, with dark blue or greenish-blue wing-covers; they are quite abundant in some moist places, where they hide under loose stones. Such beetles (Fig. 18) are frequently mailed to the office of the Entomologist to find out their names and life-history; but thus far they have never been received labeled "Kissing-bugs," although almost all other queer looking or queer acting insects have been received as such. These bombarding-beetles possess little sacs at the hind end of their bodies, in which a bad-smelling fluid is secreted, which is used as a means of defense.

In fact most of the Carabidæ are well protected by strong odor as those handling them have found out to their sorrow. But in this case the beetles squirt the nasty fluid at their enemies, and as it changes to a gas on contact with air, it looks as if the beetle



Fig. 18.—*Brachinus* species. Enlarged. After Brehm.



Fig. 19.—*Lebia grandis*, Hentz. D. of Entomology, U. S. Department of Agriculture.

were shooting in a wrong direction. A puff of smoke and a pop is the result of such an explosion. This fluid colors the fingers a persistent red, which shows that it is of an acid nature. Of course this sort of defense is very effective, and we call these beetles "six-legged skunks."

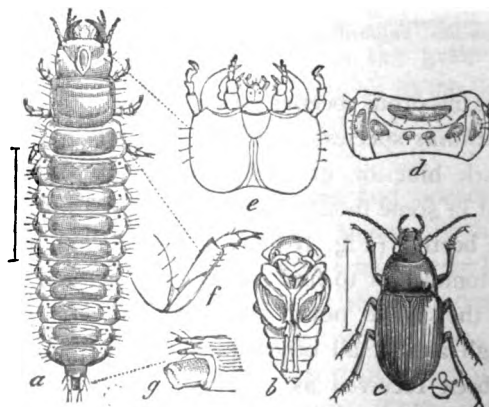


Fig. 20.—*Amara obesa*, Say. a, larva; b, pupa; c adult d, e, f, g, larva. After Riley.

A similar beetle, illustrated in Fig. 19, is the *Lebia grandis* Hentz. This similarity extends, however, only to the coloring of the insect, not to its method of defense. The beetle is very useful, and sometimes becomes quite numerous in potato fields infested with the Colorado potato-beetle. It eats their eggs as well as the young worms; other small soft-bodied insects are also pleasing to its taste.

There are other useful beetles belonging to this division, which deserve a passing notice. In fields filled with eggs of locusts we find numerous oval-shaped black beetles (*Amara obesa* Say), Fig.

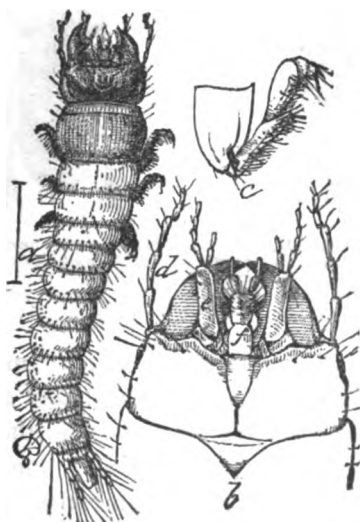


Fig. 21*. *Harpalus herbivagus*, Say. a, larva; b, head of same. Enlarged. After Riley.

20 which run about very diligently in search of food. They deposit eggs in the ground, from which yellowish-white worms, also shown in the illustration, hatch in due time. These worms search for the eggs of locusts, and devour immense numbers of them. The larvæ of another beetle, shown in Fig. 21, are also found in similar places, and also do similar good work. They transform in time into black beetles, the *Harpalus herbivagus* Say. A related beetle, the *H. pennsylvanicus* DeG., which is frequently

*In case the illustrated is enlarged, the true size is usually given by a fine line near the figure.

found in orchards eating the larvæ of the codling moth and plum-curculios, is also shown in Fig. 22.

It would take too much space to even mention all the belonging here. Most of them are useful, though a few occasionally cause some damage. The insect illustrated in (*Agonoderus pallipes* Fab.), is one of them, as it eats into the sprouting seeds of corn. This insect is at times exceedingly common, as people who have strong electric l

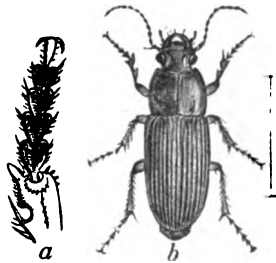


Fig. 22.—*Harpalus pennsylvanicus*. De G. a, anterior tarsus and part of tibia showing notch; b, beetle; c, larva, reduced size; d, head; e, details. After Riley.

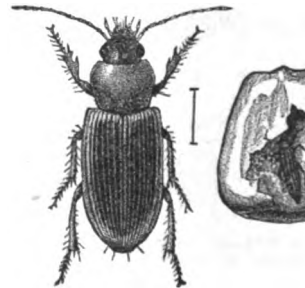


Fig. 23.—*Agonoderus pallipes*. beetle inside of corp. After Riley.

front of their houses are apt to find out. Immense numbers of them and of other insects are attracted, and sometimes they are so numerous as to cover the sidewalk with their dead and mangled bodies. Rooms with open windows, and illuminated with gas, are sure to attract multitudes of them; they seem to be of decidedly inquisitive nature, as they run over our bodies, and in search of hiding places, and in doing so cause a sensation far from being pleasant.

In a general way nearly all such insects are either beneficial or at least harmless, hence are our friends and should be treated as such.

FAMILY PREDACEOUS WATER-BEETLES.

(*Dytiscidae*).

Predaceous Water-beetles are simply ground-beetles adapted to live in water. They have the same blood thirsty

as their relatives in drier places. Such beetles are also very numerous, and are readily observed when we quietly approach a pool of stagnant or standing water. We can detect their oval and flattened bodies hanging head downwards, with the tip of their abdomen at the surface of the water. When disturbed they dive, and in doing so carry with them a bubble of air, which looks like a liquid drop of silver, and which is utilized to sustain respiration until the beetle feels safe again and rises to the surface. Such beetles are well adapted for swimming, possessing a boat-shaped body, usually quite polished, and having their long hind legs broadly flattened and fringed with stiff hairs, so that they can be used as oars. Such a leg is shown in Fig. 10, and it will be noticed how admirably it is adapted for swimming. The feelers of such beetles are long and thread-like. The males of

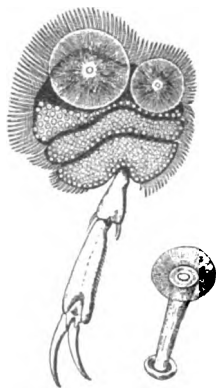


Fig 24.—Sucking disk of male *Dytiscus*. Highly magnified. After Miall.

some kinds possess a very remarkable sucking-disk (Fig. 24), which is produced by dilating the first three pairs of the front tarsi; the females sometimes have the elytra furnished with deep furrows. Both structures are of use during the mating season. All the water-beetles, and still more so their dangerous looking larvæ, which possess powerful scissor-like jaws, kept in constant motion, are savage and greedy, feeding upon tadpoles,

small fish and aquatic insects. They have no direct bearing upon horticulture, except, perhaps, by destroying large numbers of the larvæ of mosquitoes, which annoy fruit-growers as well as other people. The illustration, (Fig. 25), gives an idea of the form of such beetles and their larvæ. The larvæ, though aquatic, leave the water when ready to change to pupæ. This is performed in an earthen cell made for this purpose in adjoining dry soil.



Fig. 25.—Carnivorous Water Beetles. After Brehm.

FAMILY WHIRLIGIG-BEETLES OR "APPLE-SMELLERS."

(*Gyrinidae*).

This family is mentioned here not because its members smell like apples, the act which gives it its name, nor because they are fond of that fruit, but simply to show how certain organs can be modified for specific purposes. In these beetles we find that the eyes are completely divided by the margin of the head, so that they appear to possess the unusual number of four eyes (Fig. 7). They are also remarkable for their long front legs, which are used for grasping their food. The other legs seem to be absent, but this is not so, as they are simply folded up in the smallest possible space when not in actual use. Every one knows the social black and shiny beetles, small in size, which, however, sometimes crowd together in such numbers on the surface of o

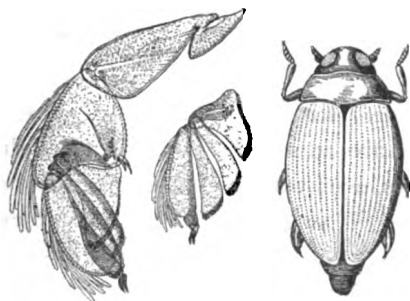


Fig. 26.—*Gyryinus marinus*. Gyll. Hind leg and tarsal joints of same separated and extended. Highly magnified. After Mfall.

lakes, especially in quiet water near the shore, that they cover many square yards. If disturbed, all dart away, tracing graceful curves on the surface of the water. The legs and the adult insect are illustrated in Fig. 26.

B. CLUB-HORNS.

(*Clavicornia*).

Club-horned beetles are very numerous, but the character expressed by the term "club-horns" is not always easily detected. These beetles are divided into numerous families (32), and some of them are of very great benefit to orchardists. Most of them, however, are scavengers, and subsist upon dead or decaying material. Some live in water, others are inhabitants of ant-nests, some prefer dung as food, others dead fungi and wood, or woollen garments and dried meat, and even collections stored in museums do not escape their hungry jaws. One family at least enjoys nothing better than leaf-lice and scale-insects, the great enemies of our fruit-producing plants. It is impossible even to mention the names of the numerous families of beetles belonging here, and only a very few of the more destructive ones will be given, so that something about the classification of beetles may be learned.

FAMILY WATER-SCAVENGER BEETLES.

(Hydrophilidae).

These beetles, some of which are quite large known, as they are attracted to the electric lights in our cities, in large numbers, even when a long distance away from pools of water. They are found in stagnant water, where they either feed on the plants growing on the bottom of such pools, or move in a peculiar manner, not swimming with strokes of body and legs, as the aquatic carnivorous beetles do, but by moving



Fig. 27.—*Hydrophilus*, adult, larva and peculiar egg-mass. After

legs alternately as if walking. They possess short clubbed feelers well hidden beneath the head, so that they are not easily detected. Their food is mostly composed of decaying matter, but if they have an opportunity to catch living prey they are slow to eat it as well. They breathe by carrying a film of air on the lower side of the body, which gives them a beautiful silvery appearance. When they need a fresh supply of

come to the surface of the water with their heads first. The illustration, (Fig. 27), shows some of the stages of the largest of these beetles.

FAMILY CARRION-BEETLES.

(Silphidae).

These well known beetles devote all their attention to destroying dead animal matter, even of the most putrid kind. A few are, however, partly vegetable feeders, and at least one is known in Europe as being very destructive in gardens. Most people have seen some of them at work burying dead mice and birds, for which reason they are called "burying-beetles" (Fig. 28). They are black, with large spots or bands of bright orange yellow; some are polished, others have a thorax densely covered with yellow hairs. If such beetles discover a small dead animal, they immediately remove the soil beneath the same, and



Fig. 28.—*Necrophorus* burying mouse, and larva. After Landols.

usually many individuals are seen working together in harmony. If the carcass has been covered up, the females deposit their eggs upon this store of food, and now leave the larvæ feed upon the buried putrid material. The strength of such beetles is remarkable, as is shown by the fact that they have been observed to roll a large dead rat several feet in order to have it rest upon a soil fit for burying. The illustration (Fig. 29). shows another of these interesting beetles, b



Fig. 29.—*Silpha* and *Hister*. After Brehm.

ing to the genus *Silpha*, the members of which are all very strong. The full-page illustration shows many of the different kinds of scavenger-insects upon a dead mole.

FAMILIES SCYMAENIDAE AND PSELAPHIDAE.

These comprise very small beetles which are usually found in ant-nests. They resemble ants in shape and color, and

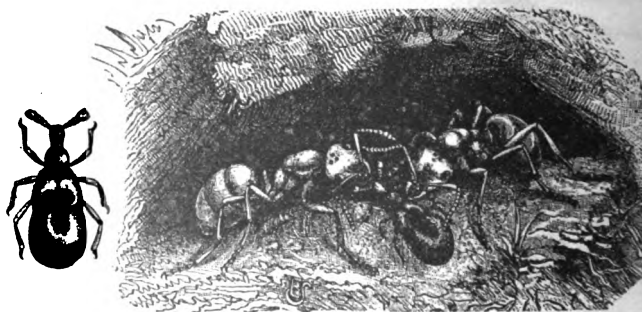


Fig. 30.—*Claviger* petted by ants. After Brehm.



A feast for scavenger insects. After Brehm.

kept, like leaf-lice, for the purpose of furnishing sweet food to their captors, the owners of the nests. Some of them are entirely blind, and most of them are taken care of by the ants, even feed them. They are of no economic importance. Fig. 30 shows one of these peculiar insects tended by ants in one of their subterranean vaults.

FAMILY ROVE-BEETLES.

(*Staphylinidae*).

This is a very large family of small beetles with a elongated slender body and very short wing-covers (Fig. 31). But notwithstanding the short elytra the beetles possess a

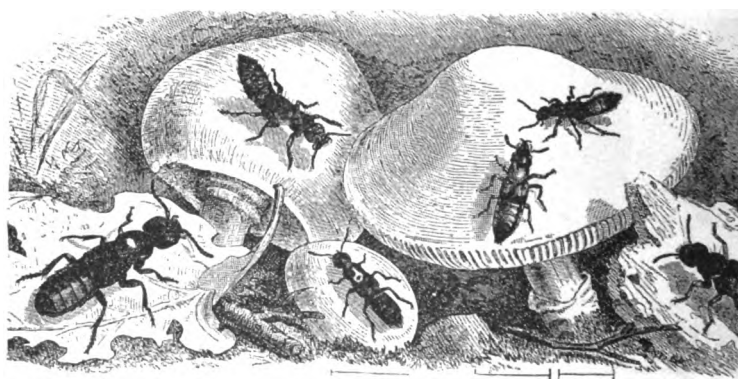


Fig. 31.—Different kinds of *Staphylinidae*. After Brehm.

true wings. Some of the larger species, measuring more than half an inch in length, assume a very threatening aspect when closely approached with the finger. Their abdominal joints being very movable, they raise the last unarmed joints, which are frequently of a contrasting color, being yellow or red, as a warning sting, and in this way they are well able to scare those that do not know them from the wasps which they imitate. Nearly all these beetles are beneficial, as they are scavengers, feeding on decaying animal and vegetable matter.

A few of them are found in blossoms, very likely eating pollen; but as flowers produce an abundance of this material the beetles cause no damage, on the contrary, they may even be useful by carrying pollen from flower to flower, thus cross-fertilizing them.

FAMILY LADY-BUGS.

(*Coccinellidae*).

These very beneficial insects are the best friends of our orchardists, as nearly all of them seem to devote their time, both as larvæ and as adults, to destroying the injurious leaf-lice and scale-insects. The beetles are rather handsome, almost always of a bright red or orange color, with intense black spots; or they are polished black with red spots. The bright colors protect them to a large extent against insect-devouring birds, since it shows them that the food is not good to eat, they having learned by experience that such bright colors coming from such insects indicate nasty odors or, perhaps, a nasty taste. At all events insects marked by such showy and conspicuous colors are not often eaten. The bodies of lady-bugs are usually of an oval or hemispherical form, very convex, and almost flat below. The short

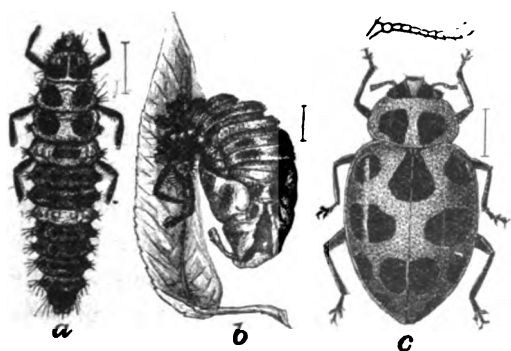


Fig. 32.—*Megilla maculata*, De G. After Division of Entomology, U. S. Department of Agriculture.



Fig. 33.—*Megilla maculata*, De G.; parasitized. After Division of Entomology, U. S. Department of Agriculture.

feet and still shorter feelers are well hidden beneath the shell-shaped head and are not visible unless the beetle is in motion. Beautiful as the adult beetles are, their larvæ are horrible-looking objects, having their surface covered with long or short spines; others are protected by being covered with fine hairs down. The pupa is not formed in the soil but inside the larval skin, which splits open at the back, surrounding the pupa with a tight-fitting over-coat with the front not closed by buttons. In other cases the larval skin is forced backwards, and remains as a little crumpled pad about the posterior end. The larval skin in the former case is tightly fastened to the plants, and remains in this position sometimes long after the beetles have left both the plants and larval skins.

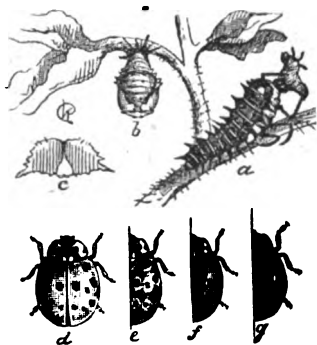


Fig. 37. — *Anatis 15 punctata*, Say.
After Riley.



Fig. 34. — *Hippodamia cincta*, Guer.
After Riley.



Fig. 36. — *Coccinella sanguinolenta*, L.
After Riley.

Lady-bugs are well-known, and may be seen in large numbers upon trees infested with plant-lice and scales. Both larvæ and adults eat these beings very greedily, and destroy immense numbers of them. Without their presence and assistance plant-lice increase so rapidly that in a very short time the plants would be entirely covered with them, and as a consequence might be killed very much, or would even be killed.

As the life-history of all lady-bugs is very similar, it is unnecessary to describe in detail all the species found upon

fruit-producing plants. A number of them have been illustrated, and readers can learn their shape, etc., by consulting the illustrations (Figs. 32-39). The fruit growers of California ought to bless such insects, as they helped them to destroy a most destructive scale-insect which threatened to ruin the fruit-growing interests in that state. For this purpose a lady-bug, (*Pedalia cardinalis*), and several other kinds were imported from Australia, where they were known to kill this scale, and in less than two years the pest was almost exterminated. The "twice-stabbed lady-bugs," natives of the United States, also assisted in the good work, and one of them, the *Chilocorus bivulnerus* Muls., is fairly common in Minnesota (Fig. 38). The "two-

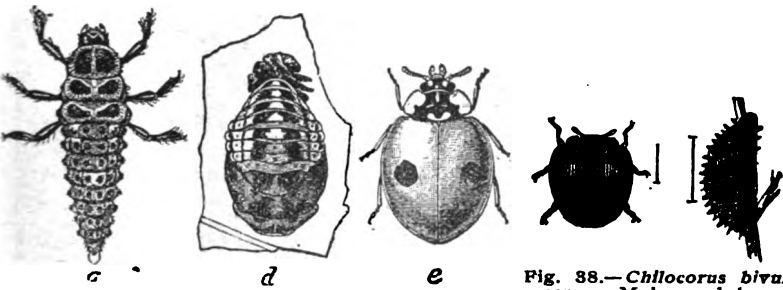


Fig. 36.—*Adalia bipunctata*, Linn. After Riley.

Fig. 38.—*Chilocorus bivulnerus*, Muls., and larva. After Riley.

spotted lady-bug," (*Adalia bipunctata* Linn.), which was rather uncommon until a few years ago, is now found everywhere in our state in many interesting variations; it is the only one of the lady-bugs that here enters houses for hibernation, and is frequently mistaken for the destructive carpet-beetle, and killed on that account. It is a reddish-yellow beetle with a single black spot on each wing-cover (Fig. 36).

Some species of the lady-bugs are so minute that they are barely visible, as is shown in Fig. 39, which shows some of these small black beetles, with their larvæ, in the act of eating the dreaded San Jose scale, yet, notwithstanding their small size, they do much good. All the above-mentioned beetles should be protected, since they are most useful friends.

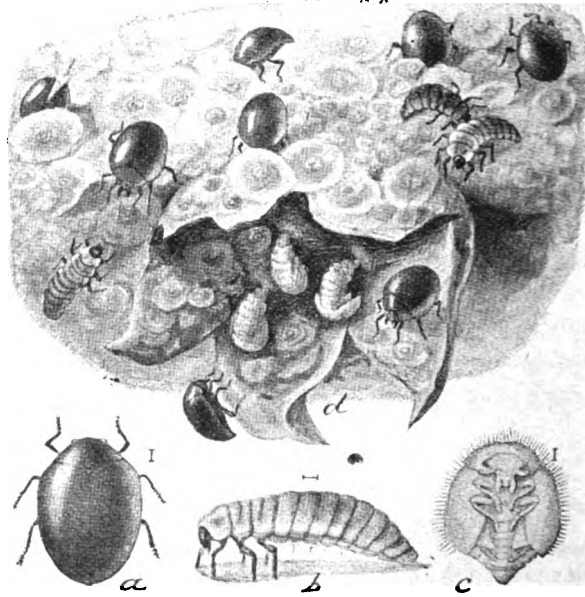


Fig. 39.—*Pentilla misella*, Lec.—a, beetle; b, larva; c, pupa; d, blossom eaten by the *Pentilla*. (After Howard and Mariatt), Division of Entomology, Department of Agriculture.

But there is one exception, one black sheep in the family. This exception is a plant-feeding species (*Epilachna* Fab.), happily not as yet found in our state. But as it will less find its way to our fields we should be on our guard. The lady-bug, both as larva and as adult, feeds upon squashes, melons, and melons. The beetle is yellowish, with large black spots.

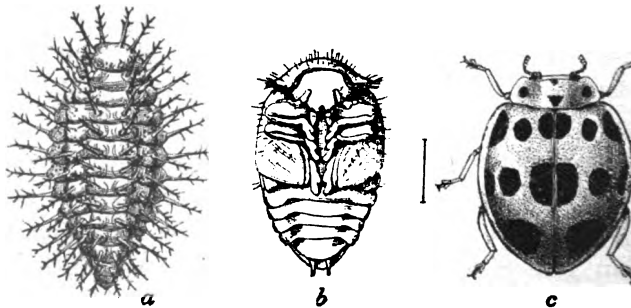
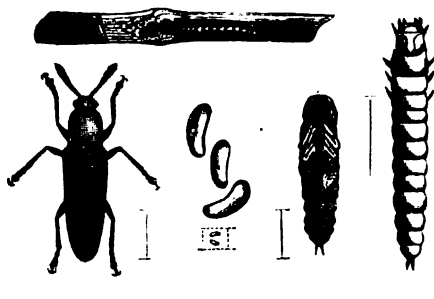


Fig. 40.—*Epilachna borealis*, Fab. After Division of Entomology, U. S. Department of Agriculture.

and is not as shiny as the other lady-bugs of equal size, but is covered with a fine pubescence. The larva is yellow, and clothed with forked spines, as may be seen in the illustration (Fig. 40). There is no doubt that in case of necessity, or for lack of proper animal food, some of the lady-bugs will also eat pollen, but their usual food consists of plant-lice, scale insects, and the eggs and soft bodies of other insects.



♂

Fig. 41.—*Languria Mozardi*, Lat. After Division of Entomology, U. S. Department of Agriculture.

The families *Endomychidae* and *Erotylidae* also contain a number of brightly colored beetles with long feelers. But none are very common or destructive, with the exception of some beetles belonging to the genus *Languria*, one of which has in the larval state the bad habit of boring in the stalks of clover. It is shown in Fig. 41.

FAMILY CUCUJIDAE.

These beetles, usually of a flat and elongated form, are found under the bark of trees, and are believed to be mostly carnivorous, but others are known to feed upon stored grain. Several species have this bad habit, but the most important one is the "Corn Silvanus" (*Silvanus surinamensis* Linn.), shown in Fig 42. It is a dark brown and flat beetle, with saw-like edges on the pro-thorax. It also feeds on dried fruit. In such a case it can be killed by putting the infested fruit in a tight-fitting wooden box, and by pouring a wine-glass full of bisulphide of carbon in the larger box the fumes thus produced will kill all intruders.

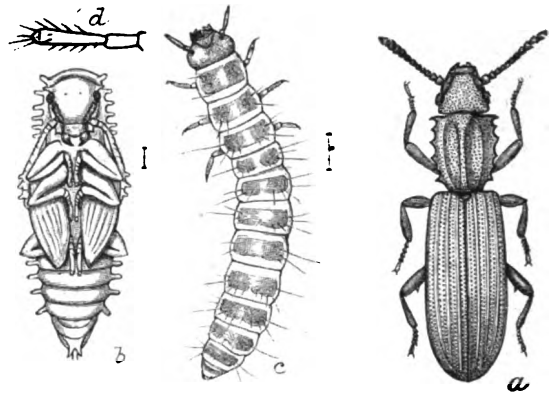


Fig. 42.—*Silvanus surinamensis*, Linn. After Division of Entomology, Department of Agriculture.

There are many of these and other insects found on dried fruit since this is palatable to six-legged beings as well as to two-legged ones. The fumes mentioned above kill all insects, without leaving any odor or flavor behind, but whether the infested fruit with the dead insects in it is fit for human food must be decided by the individual who wishes to eat it.



Fig. 43.—*Laemophloeus fasciatus*, Mels. Original.

Another species, the *Laemophloeus fasciatus* Mels., is illustrated in Fig. 43, is found under bark, but is also very common near saw-mills, especially in those in which hard wood is sawed.

In running over persons engaged in mills it will bite, even without provocation, and may cause bad sores. It is a small and flat beetle, of a light brown color, with highly polished wing-covers, with a light space upon each. Related beetles are found also in stores of grain and dried fruit.

FAMILY DERMESTIDAE

(*Larder-beetles; Carpet-beetles; etc.*).

Most of the beetles composing this family feed upon decaying substances, or on skins, furs, and dried animal matter of all kinds. The wing-covers completely cover the abdomen, and are not

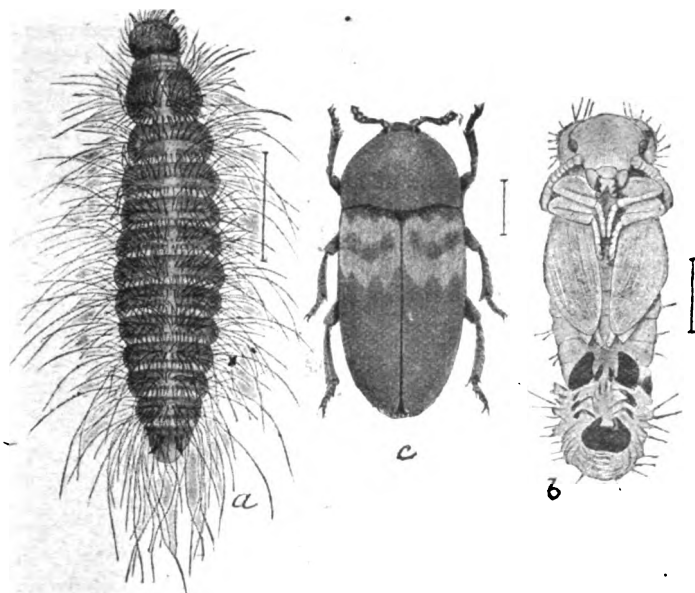


Fig. 44.—*Dermestes lardarius*, Linn. After Division of Entomology, U. S. Department of Agriculture.

shorter than it, as was the case in most of the scavenger beetles mentioned thus far. They are usually small, but few reaching a length of one-third of an inch. They are oval or elongated, ornamented with pale gray, yellow, or white markings formed by minute scales which rub off very easily, and are sometimes

arranged very prettily. Most of the insects pretend to be dead when disturbed, and roll upon their back, on which they remain for a long time. To this family belongs the Larder-beetle, (*Dermestes lardarius* Linn.), which is shown in Fig. 44. Both larvae and adults enter houses, and for no good purpose, since they destroy stored provisions, especially those composed of animal matter, as smoked meat, hides and feathers. The *Museum Pest* destroys collections, and the *Carpet-beetles* (*Anthrenus scrophulariæ*)

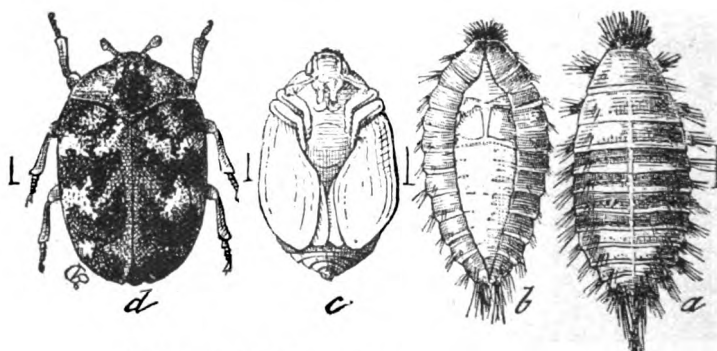


Fig. 45.—*Anthrenus scrophulariæ*, Linn. After Riley.

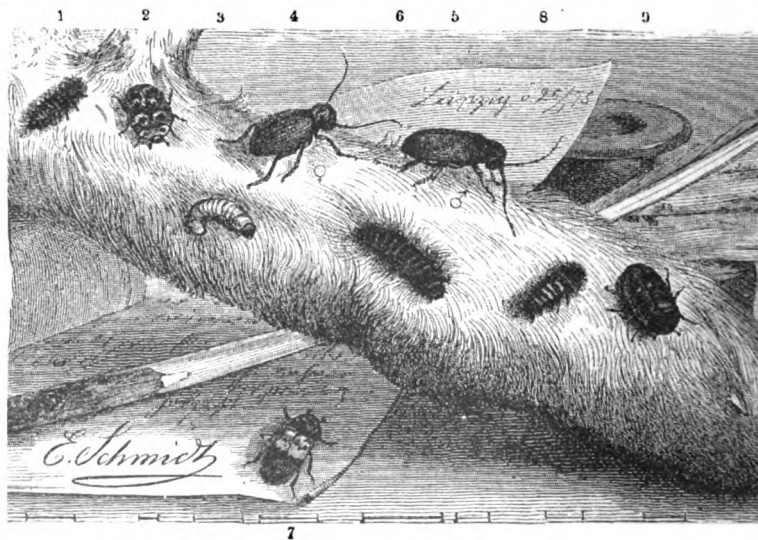


Fig. 46.—*Dermestidæ* and *Ptinus* at work. After Brehm.

Linn), illustrated in Fig. 45, are well named, since they eat woolen carpets and similar material, often causing great losses. In a state of nature such beetles are useful as scavengers, as they soon remove bad-smelling and unsightly substances. A number of these beetles of similar habits are also shown in Fig. 46.

But there is one exception. One beetle belonging to this family shows better taste by eating raspberries.

THE RASPBERRY FRUIT-WORM.

(*Byturus unicolor* Say).

This sensible insect, about three-twentieths of an inch in length, is yellowish, and is covered with short, silky, gray hair. It feeds on the flowers of the red raspberry, in which the eggs are also laid. Here the larvæ, which are white and nearly naked grubs, hatch, and enter the inside of the berry, where they rapidly grow. When such a berry is picked the culprit is found inside, clinging to one of the sides of its pleasant dwelling place. The beetle is not common enough in Minnesota to be of any great economic importance; it is shown in Fig. 47.

FAMILY HISTERIDÆ.

Members of this family of beetles are usually small, short, rounded or angular insects, of a more or less polished black, bronze, or greenish color, although some are brown or marked with red, as the one shown in Fig. 29. The elytra are finely striated or punctured, and do not cover the entire abdomen, but are cut off squarely, exposing the last two segments of the same. These are also very hard, and look like the wing-covers. Below the elytra are ample true wings. The legs, which are adapted for digging, as well as the short feelers, can be hidden in depressions, and if this is the case the entire insect looks very much like a black seed, especially as it also pretends to be dead when captured. Such beetles abound about carrion and other decomposing substances. The whitish and maggot-like larvæ are found in similar material, but occur also in over-ripe fungi, fruit, and under loose bark of trees.

FAMILY NITIDULIDAE.

(Sap-beetles).

Sap-beetles are also small, more or less flattened in which in most cases have the tip of the abdomen exposed beyond the wing-covers. The pro-thorax is frequently provided with wide and thin margins; the legs are not specialized for digging purposes. The beetles, both larvæ and adults, feed on decaying or fermenting sap, fruit, or fungi; a few prefer carrion, and others are found among stored grain. They are especially numerous among rotting fruit and vegetables, and about trees that have been injured by bruising, and in such places they crowd together in large numbers to obtain the fermenting sap; beneath stored over-ripe fruit they also gather.



Fig. 47.—*Byturus unicolor*, Say. After Saunders.



Fig. 49.—*Carpophilus hemipterus*, Linn. After Smith.

A number of these beetles deserve a short description. They are frequently found about our fruit-producing plants. *Carpophilus brachypterus* Say (Fig. 48, plate 1.), was very common during the last two seasons in the flowers of the rose. Here they enjoyed a meal of pollen, which covered them to an extent as to hide them effectually. Going from flower to flower, they no doubt do some good, but some also show no appreciation of a good thing by eating holes in the petals, and thus, however, causing any visible damage, as the petals soon drop away anyhow. Another species, the *C. hemipterus* Linn., is frequently very abundant in stored fruits, and seems to enjoy a box of

beyond anything else. It is illustrated in Fig. 49, to show the structure of such beetles, which could not be shown in Fig. 48.

FAMILY TROGOSITIDAE.

(*Cadelles*).

Ips fasciatus Oliv., shown in Fig. 50, is sometimes very abundant among and beneath heaps of carrots. It is a rather pretty insect, shining black with two bright, interrupted, reddish or orange bands across the elytra. None of these insects are espe-

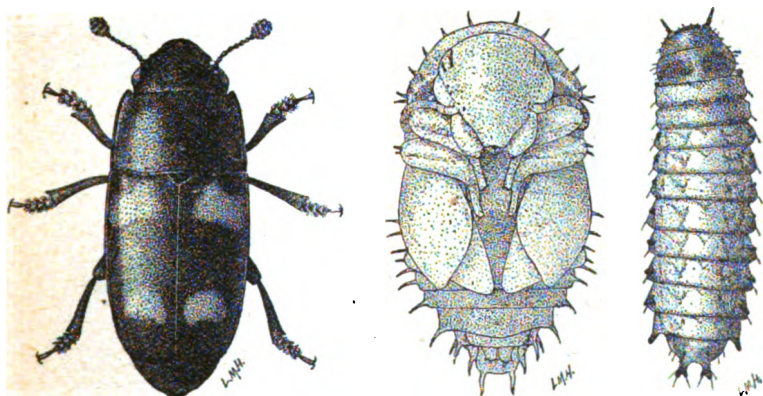


Fig. 50. *Ips fasciatus*, Oliv. After Forbes.

cially injurious. This can not be said about the nearly related species of *Tenebrioides*, frequently called "cadelles." These insects are found in large numbers in barns and mills, where they feed on grain, meal and flour. In mills they can cause great damage, not so much by eating the flour as by eating holes in the fine and expensive bolting silk. One species (*T. mauritanica*, Linn.), is shown in Fig. 51.

Such beetles are sometimes found in most unexpected places. The illustration (Fig. 52) shows the work done by their larvæ in some books stored in a bin. Whether these insects were after knowledge, and studied a Norwegian book or not, is left an open question.

C. SAW-HORNS.

(Serricornia).

They contain numerous families of beetles, some need description, as many very injurious insects belong to this group.

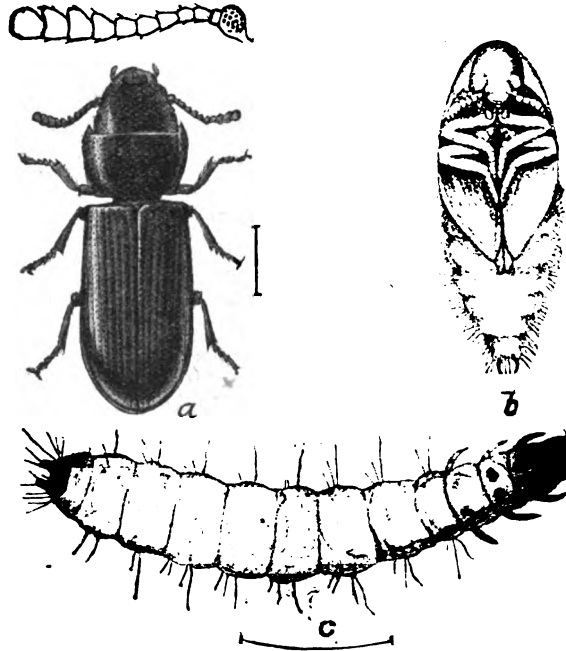


Fig. 51.—*Tenebrioides mauritanica*, Linn. After Division of Entomology, Department of Agriculture.

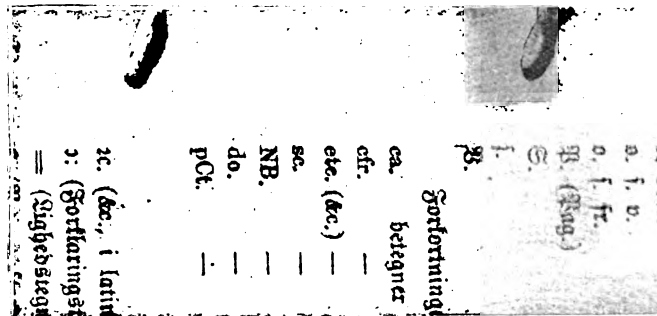


Fig. 52.—*Tenebrioides mauritanica*, Linn. as a student. Or

FAMILY ELATERIDAE.

(*Snapping, Clicking, or Spring-beetles*).

Notwithstanding the large number of beetles that form this family, they are nearly all readily recognized in all of their stages, and every boy knows the acrobatic performances of the adult snapping-beetles. If touched ever so lightly the beetle drops to the ground, usually landing upon its back; after remaining perfectly quiet for a time, as if dead, we hear a sudden click, the beetle pops into the air, and falling upon its short legs, runs away. When we study the under side of the beetle to discover the means which enable it to act in this peculiar fashion, we find that the pro-thorax is loosely jointed to the rest of the body, and that on its under side there is a curved horn which fits into a cavity of the meso-thorax (Fig. 53). When such a beetle is laid



Fig. 53.—Elater ready to snap. After Smith.

on its back it bends in such a way as to bring the tip of the curved horn to the edge of the cavity, and by a sudden release of muscular tension, this tip slips and the insect is thrown into the air.

Most of our snapping-beetles are small, or of medium size, but a few are quite large, sometimes reaching two inches in length. As a general rule they are of a uniform brownish color; some are black or grayish, and still others are gayly colored, even metallic. The very elongated body tapers more or less towards each end, and is sometimes flattened. The feelers are moderately long, more or less serrated, very much so in the males of some rather uncommon species. The outer angles of the very wide pro-thorax are usually prolonged into points, which curve around the edge of the wing-covers.

The larvæ of the click-beetles live in the ground and in decaying wood; they sometimes eat other insects found in similar places. These larvæ have been named "wire-worms," a name that well describes the form and hardness of their bodies. They are long, narrow, worm-like, very even in width, decidedly hard, and of a brownish or yellowish white color. Besides a stumpy projection on the last joint, acting as a sort of prop for the long abdomen, they have only the usual three pairs of jointed legs in front. Nor do they need long legs, as they live well hidden in the ground or in rotten wood. They are mostly vegetable feeders, and there are but few cultivated plants which they do not injure. What makes it worse is the fact that they are so well hidden, and that they cause most injuries at a time when the plants are still young and tender; in fact, even seeds are frequently destroyed before they have germinated. In this way fields of corn and other grain are more or less frequently destroyed by wire-worms, and as we have over 500 species of such noxious beetles in the United States alone, the damage caused by them is not slight. A few of these wire-worms are, however, somewhat beneficial, as they hunt for and eat wood-boring larvæ.

The larva of one of our largest species, the Eyed Elater, (*Alaus oculatus* Linn.), is one of the few which largely subsists upon other insects; at least all the larvæ kept by the writer in decaying wood would soon perish if not provided with living insects, which were soon discovered by these cannibals and devoured. The large, yellowish-brown larva of the *Alaus* transforms to a pupa, and later into a most striking beetle (Fig. 54), black in color, the elytra covered with fine lines and flecks of white scales arranged in ridges. But the most remarkable markings are a pair of large velvety-black spots, encircled with white, upon the pro-thorax, which spots are frequently mistaken for eyes; the true eyes are, of course, situated at the usual place on each side of the head, and are rather small.

Such wire-worms as live in the ground, and which feed upon the roots of plants, sometimes causing great losses to cereals and to other cultivated plants, as the strawberry, are exceedingly dif-

difficult to reach with any material that will kill them. In fact, most of the many remedies which at one time or another were claimed as infallible, have proven to be of very little benefit.

The life-habits of the subterranean species may be stated in general to be as follows: the beetles, which appear very early in spring, and which may be found under loose bark, under stones and boards, or in fields in which the sod has been turned over, fly about late in May or early in June, during the warmer portions of the day. After copulating they deposit their eggs in grass-land, or among weeds, or wherever there is an abundant vegetation of a

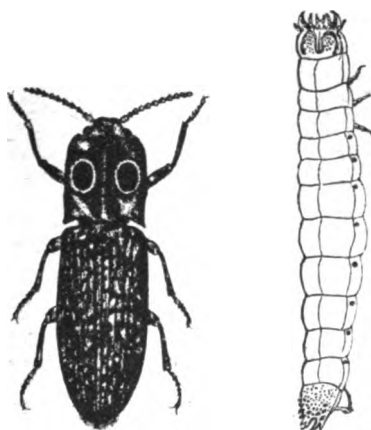


Fig. 54.—*Alaus oculatus*, Linn., and larva. After Harris.

grassy nature. During midsummer the larvæ hatch and feed upon the roots of many plants for two or three years, when they reach their full size. They change to pupæ early in fall, and soon afterwards to adults; these, however, do not leave the ground until the next spring. From this life-history it will appear that we can not directly apply any poison that will kill the larvæ. By attracting adult insects to bait during the spring we may kill a few. The only possible method to get rid of them is good cultivation and proper rotation of crops. Meadows infested should be plowed during the fall, when the full-grown larvæ,

pupæ and adults are killed, at least many of them are. But the younger ones are not, and as they remain in the larval stage for two or three years, the fall plowing should be repeated many times. Professor Smith recommends the use of crimson clover, which should be sown soon after the beetles have laid their eggs, and it should be harvested and plowed under so as to prevent the development of the larvæ. In our fruit gardens the wire-worms can only be destroyed by constant attention.

Some species also feed upon flowers and fruit, but the dam-

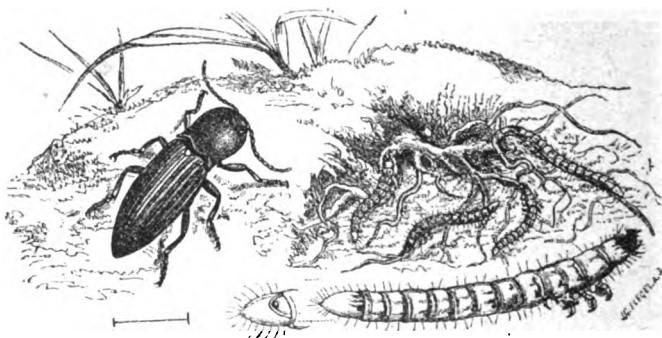


Fig. 55.—Wire worms at work. After Brehm.

age caused by them is slight. Fig. 55 shows a click-beetle with a number of larvæ at work, and Figs. 56, 57 and 58 show the adults of some very injurious species found in Minnesota.

A few members of this family have the pleasant habit of eating the eggs of our destructive locusts, hence are decidedly beneficial. The larvæ of *Cryptohypnus bicolor* Esch., which has this very commendable habit, is shown in Fig. 59.

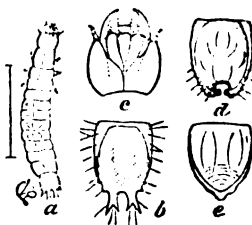


Fig. 59.—*Cryptohypnus bicolor*, Esch., larva. After Riley.

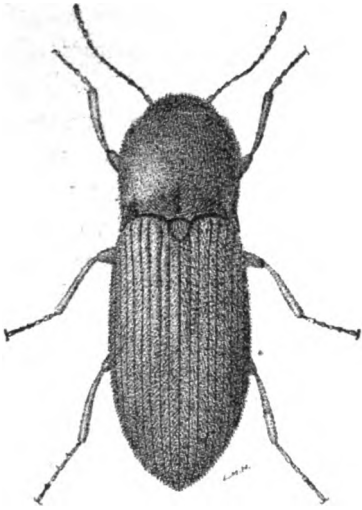


Fig. 56.—*Agriotus mancus*, Say. Greatly enlarged. After Forbes.

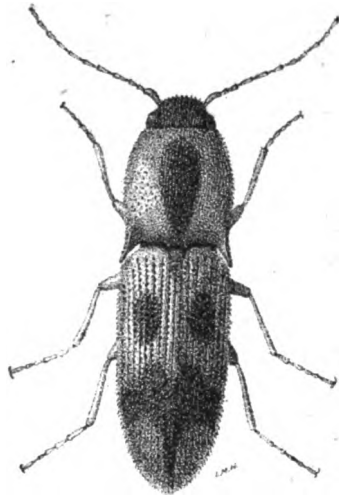


Fig. 57.—*Drasteria elegans*, Fab. Greatly enlarged. After Forbes.

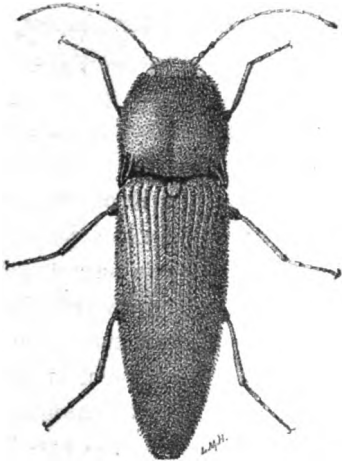


Fig. 58.—*Melanotus communis*, Gyll. Greatly enlarged. After Forbes.



Fig. 60.—*Pyrophorus noctilucus*. Natural size. After Brehm.

In Florida and Texas occur snapping-beetles which are very luminous; others very much larger occur in the tropics, and some of our soldiers have no doubt seen such insects as the one illustrated in Fig. 60, which produces a very strong greenish light.

The writer has kept such luminous beetles for a long time in the hollow joints of sugar canes, much to the delight of visitors. The Cuban ladies make a singular and pleasing use of these living gems by keeping them in little lace pockets upon their dresses, or arrange them as a fillet for their hair. A ballroom with numerous dancers wearing such "flashing" jewels is a very peculiar sight. Fig. 60 shows one of these large beetles; the two whitish spots, one on each side of the pro-thorax, and the posterior part of the under side of the abdomen, are luminous.

FAMILY BUPRESTIDAE.

(*Flat-headed Borers*).

These beetles, also called "*Metallic Wood-Borers*," and "*Saw-horned Borers*," resemble the click-beetles in shape, being usually rather long and narrow; their bodies are hard and compact, frequently looking as if cast of bronze. Their feelers are rather short, and serrated on their inner edge; the first and second abdominal segments are soldered together on the ventral side; the head is deeply inserted in the pro-thorax, and the latter broadens but slightly behind, fitting tightly over the base of the wing-covers. The beetles do not possess the power of springing when placed on their backs. The colors found in this family of beetles are richer than those found anywhere else in nature; some species are pale brown or gray with brassy or coppery reflections, others have the entire surface minutely roughened and indented, looking like beaten metal. Still others are blue, green, violet or golden, burnished in spots, or covered with delicate shingle-like scales, seemingly made of polished metal. Such beetles are diurnal insects, flying about during the hottest part of the day, or disporting themselves upon the trunks of trees, running about swiftly, or resting, always exposed, as if proud of their beauty. Some of them are very active, almost as much so as tiger-beetles, and use their wings with great ease; others drop to the ground when disturbed, or feign death, not trying to escape by flight.

Most of the larvæ of these borers live inside the wood of trees, more especially beneath the bark; others are gall-makers, or even leaf-miners. Their larvæ are very peculiar beings, being characterized by an enormous expansion of the first thoracic joint, from which the two posterior joints taper abruptly to the slender and cylindrical abdomen. In other cases all three thoracic joints are more or less expanded, though in some cases they are also normal. On account of this flattened appearance such larvæ are frequently called "flat-headed borers," a name very expressive, though by no means correct, as the head itself is not flattened, but appears as a small appendage upon the anterior edge of the flattened joint or joints. Sometimes they are also called "tad-poles," for self-evident reasons. The larvæ of typical *Buprestidae* possess no legs; but those of the mining species have cylindrical bodies with three pairs of legs. The adult forms of these latter are also much shorter than is usual in this family. "Flat-headed Borers," sometimes named "Hammer-heads," infest not only trees, shrubs and vines, but sometimes even herbaceous plants. Some prefer dying wood, others attack apparently healthy and vigorous plants. The pupa is formed inside the burrow or mine made by the larvæ, and is of the usual form.

Some of the worst pests of fruit-producing plants belong to this family of insects, and the more important will be described and illustrated.

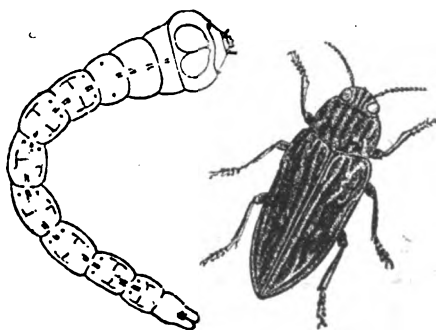


FIG. 61.—*Chalcophora* species. After Brehm

The largest of our common Buprestids is the *Vin*
prestid (*Chalcophora virginiensis* Drury). It is very
 wherever pine trees grow in forests. It is a copper-
 sect, with the elytra deeply and irregularly furrowed
 væ are very destructive to pines, but are also found
 trees. A similar European species is illustrated in
 The genus *Dicerca* contains a number of kinds of a n
 form, which have the elytra so strongly narrowed
 tips as to appear like tails. The wing-covers are ve
 irregularly marked with elevated spots and ridges, cop
 or brassy, with greenish reflections. Their larvæ infes
 of trees, among them the peach, plum, cherry, hickory
 maple.

THE DIVARICATED BUPRESTIS.

(*Dicerca divaricata* Say).

This beetle is fairly abundant in Minnesota, and
 trated in Fig. 62; it is from seven to nine-tenths of



Fig. 62.—*Dicerca divaricata*, Say. After Division of Entomology,
 ment of Agriculture.

length, copper-colored, with brassy reflections, and t
 ered with little pits. The thorax is furrowed in the r
 elytra contain numerous impressed lines, and small
 blackish spots; the tail-like tips of the elytra are blunt,
 apart a little like a swallow-tailed coat. Such beetles
 not very often, however, sunning themselves during
 and August on the trunks and limbs of old cherry

trees; or they are found running up and down the trunks, enjoying the sunshine.

The eggs are deposited in the crevices in the bark of such trees, also in that of the peach. Here they hatch, and the young larvæ eat their way through the bark, and hereafter live in and destroy the sapwood underneath. The larva has the general appearance of a flat-headed borer.

THE FLAT-HEADED APPLE-BORER.

(*Chrysobothris femorata* Fab.).

The members of the large genus *Chrysobothris* are quite flattened above; the wing-covers possess irregular depressions and elevations, and the pro-thorax has curved sides and is narrowed behind. The species under discussion is well illustrated in Fig. 63. It measures from three-eighths to half an inch or more in

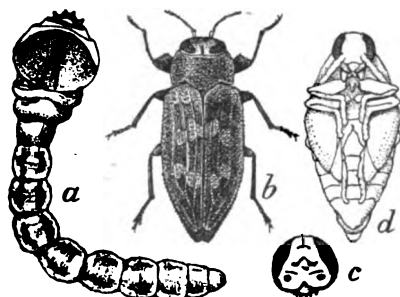


Fig. 63.—*Chrysobothris femorata*, Fab. Enlarged. After Division of Entomology, U. S. Department of Agriculture.

length, is of a flattish, oblong form, shines greenish-black, and has three raised lines on each of the wing-covers, the outer two interrupted by two impressed transverse spots of a brassy color, which divide each wing-cover into three almost equal portions. The under side of the body and the legs are of burnished copper; the feelers are green. The insect varies greatly in size, and there are a number of variations found in the United States, some being very much brighter in colors than others. The name, "flat-headed apple-tree borer,"

is somewhat misleading, as this insect is by no means confined to the apple, but injures a great variety of orchard and forest trees. It is one of the most injurious of all buprestids. Professor Saunders, in his book, "Insects Injurious to Fruits," a book that ought to be in the hands of every fruit-grower, gives the following life-history of this pest:

"This pest is common almost everywhere, affecting alike the frosty regions of the North, the great West, and the sunny South. It is much more abundant than the two-striped borer, and is a most formidable enemy to apple-culture. It attacks also the pear, the plum, and sometimes the peach. In the Southwestern States it begins to appear during the latter part of May, and is found during most of the summer months; in the Northern States and in Canada its time of appearance is June and July. It does not confine its attacks to the base of the tree, but affects the trunk more or less throughout, and sometimes the larger branches.

"The eggs, which are yellow and irregularly ribbed, are very small, about one-fiftieth of an inch long, of an ovoidal form, flattened at one end, and are fastened by the female with a glutinous substance, usually under the loose scales or within the cracks and crevices of the bark; sometimes singly, at other times several in a group. The young larva soon hatches, and, having eaten its way through the bark, feeds on the sap-wood within, where, boring broad and flattish channels, a single specimen will sometimes girdle a tree. As the larva reaches maturity it usually bores into the more solid wood, working upward, and, when about to change to a pupa, cuts a passage back again to the outside, eating nearly, but not quite through the bark. Within its retreat it changes to a pupa, which is at first white, but gradually approaches the color of the future beetle, and in about three weeks the perfect insect emerges, and, having eaten through the thin covering of bark, escapes and roams at large to continue the work of destruction.

"The mature larva is a pale-yellow, legless grub, with its anterior end enormously enlarged, round, and flattened. At 4,

in figure 63 the upper side of the anterior swollen portion of the body is shown. Whether this larva requires one or two seasons to reach maturity has not yet been determined with certainty, but the opinion prevails that its transformations have been completed in a single year.

“Remedies.”—One might reasonably suppose that this larva, in its snug retreat, would be safe from the attack of outside foes; but it is hunted and devoured by wood-peckers, and also destroyed by insect parasites. A very small fly, a species of Chalcid, destroys many of the larvæ; besides two larger parasites have been bred from them, one of which, *Bracon charus* Riley, is rep-

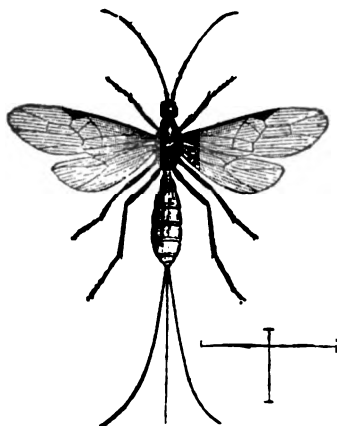


Fig. 64.—*Bracon charus*, Riley. After Riley.

resented magnified in Fig. 64, the hair-lines at the side showing its natural size. The other species, *Cryptus gallator* Say, is somewhat larger; they both belong to that very useful group of four-winged flies known as Ichneumons.

“Although healthy, well-established trees are not exempt from the attack of this enemy, it is found that sickly trees, or trees newly transplanted are more liable to suffer, especially on the southwest side, where the bark is often first injured by exposure to the sun, resulting in what is called sun-scald. All trees should be carefully examined early in the fall, when the young

larvæ, if present, may often be detected by the discoloration of the bark, which sometimes has a flattened and dried appearance, or by a slight exudation of the sap, or by the presence of the saw-dust-like castings. Whenever such indications are seen, the parts should at once be cut into with a knife and the intruder destroyed. As a preventive measure there is perhaps nothing better than coating the bark of the trunk and larger branches with a mixture of soft soap and a solution of soda."

Professor John B. Smith, in his valuable book, "Economic Entomology," in speaking of remedies against this or similar borers, says:

"In general we are very helpless against boring larvæ once they get into the trunk of a tree. Cutting out is a tedious process, even if the location of the larva is easily discoverable, which it often is not. We must, therefore, try to prevent their entrance, and this may be done more or less completely by mechanical means. As against the larger species—i. e., against all except *Agrilus*—a wire mosquito netting loosely encircling the trunk, so as not to touch it anywhere, is a complete protection. The insects lay their eggs under a bark scale, or on smooth bark gnaw a little hole in which the egg is laid, and if access to the bark is prevented, they seek other localities. The wire must be tied at the top to prevent beetles from getting under it, and must extend under ground an inch or so. In this way we not only prevent new infestation, but any beetles that may emerge from the trunk will be hopelessly imprisoned, and will die without a chance to reproduce.

"Instead of wire-netting, tarred paper or even newspapers tightly wrapped around the trunk and branches will answer an excellent purpose, needing renewal each year, however, where the wire-netting lasts several seasons. Thorough white-washing offers a large measure of protection, since the adults will not voluntarily eat through a coat of it, and the larvæ can not do so when first they emerge from the egg. The whitewash can be applied with a knapsack pump through a Vermorel nozzle, and a little Paris-green adds greatly to its effectiveness. It should be renewed

every week or so till the middle of July, when the danger from these flat-headed borers may be considered at an end; and it has the advantage of protecting the branches as well as the trunk. The admixture of a little glue or salt will improve its adhesive and lasting qualities.

"A strong fish-oil soap, say one pound in one gallon of water, is also effective, and may be applied in the same manner. It forms a film of soap over the bark, and is repellent to the beetles as well as fatal to the young larvæ. The admixture of an ounce of crude carbolic acid to a gallon of suds is advantageous. This mixture should not be applied to leaves or on young shoots, as it would probably cause injury. As these remedies are all preventive rather than curative, they must be promptly and thoroughly applied, and success will be in proportion to the thoroughness with which the work is done. Instead of any of the preceding methods, "insect lime," or "dendrolene," may, with proper precautions, be employed on the trunks and larger branches, and, practically, this is the best material for use against the "sinuate pear-borer." It can be easily applied, remains effective for weeks, and one application, properly made at the right time, will protect the trees for the season. As against the pear-borer, it should be applied not later than May 15th, and kept intact until June 15th, when all danger from that pest is over."

Among the smaller species of beetles of this family are some that are very destructive, and it seems that more and more of them become so where the country is more densely settled, and where the native forests give place to cultivated fruit-trees. Still other species find their way to this country with imported trees and plants; and they soon become more destructive here than in their native home, very likely because their insect-enemies do not follow them at the same time.

The genus *Agrilus* contains a large number of species, which differ from those mentioned before by their slender, cylindrical form, with a squarely truncate head, seemingly cut off in front, and with elytra much narrower at the tips.

THE RED-NECKED BLACKBERRY-BORE.

(*Agrilus ruficollis* Fab.).

This very common beetle, much more common in Minnesota than most people would believe, is found wherever blackberries and raspberries occur. In the burned over regions about Hinckley, where a dense growth of these plants has covered the ground since the fire, the writer has seen small plants of raspberries upon the leaves of which he could count, not dozens, but hundreds of these pretty insects disporting themselves in the bright sunlight. They are very active, flying away when disturbed, or, dropping to the ground as if dead, are difficult to discover among the dead material found under such plants. Of course wherever they are found in such numbers they must be injurious.

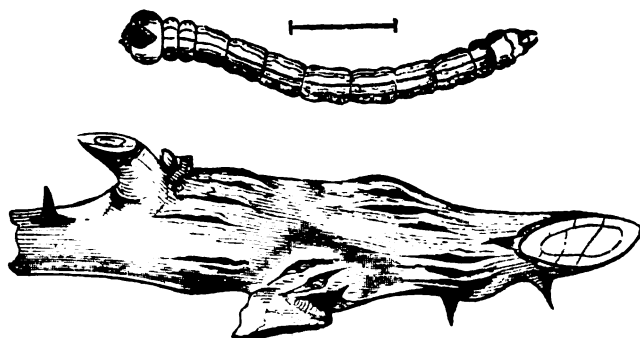


Fig. 65.—*Agrilus ruficollis*, Fab. Gall and larva. After Riley.

Sometimes the presence of their larvæ can be readily detected by the swollen appearance of the vines (Fig. 65), which look gouty, hence the name Raspberry Gouty-gall. This swelling is caused by the constant irritation caused by the larva inside. The swollen portions of the cane are not smooth, but have the surface roughened with numerous slits and ridges. When we cut under such ridges we find a burrow under each of them, and in it, or in the soft adjoining substance, we find the culprit. It

is a peculiar worm, with an almost thread-like, pale-yellowish or white body, with the anterior segment enlarged and flattened. The small head is brown, the powerful jaws are black, and the tail is armed with two slender dark-brown horns, each with three blunt teeth on the inner edge. When this worm is mature it measures about six-tenths of an inch in length. But not all the worms form such galls; many can be detected in canes not showing any swellings.

While still young the larvæ inhabit mainly the sap-wood, and following an irregular spiral course, they frequently girdle and destroy the cane. In most cases a number of worms are found in a single cane. Early in May the full-grown larva enters deeply into the pith of the cane, and here it changes to a pupa, from which the adult escapes soon afterwards.

The eggs are deposited early in summer, mostly during the month of July; they are laid on the young canes.

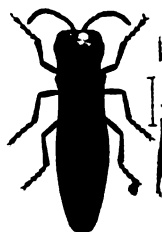


Fig. 66.—*Agrilus ruficollis*, Fab. After Riley.

The beetle is a rather beautiful insect with velvety brownish-black wing-covers, a rather small, dark, bronzy head, and a very bright coppery neck or pro-thorax; the underside is of a uniform shining black color; it measures about three-tenths of an inch in length, and is shown in Fig. 66.

Prof. Smith, who has closely studied the life-history of this beetle, writes that "it is good practice to cut out all galled canes early in spring, and burn them. Trimming is done at this time as a matter of regular cultivation, and the galls are then easily seen.

No "galled" cane ever ripens a fair set of berries, and it might as well be cut out at once. Another satisfactory method is to cut off all the new shoots at the surface of the ground about the end of June. At this time all the beetles have laid their eggs,

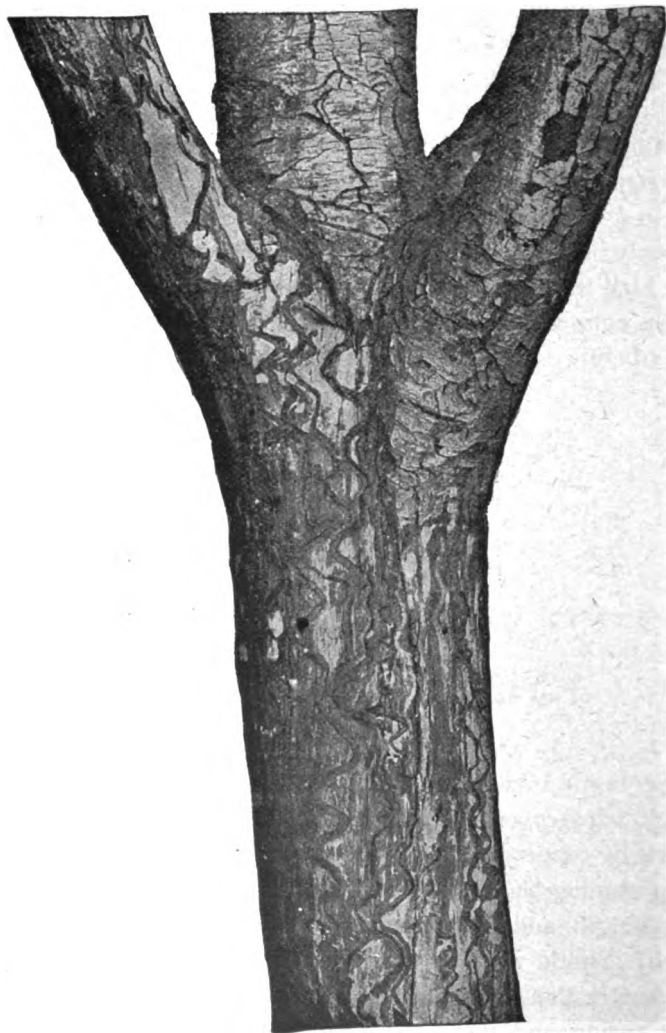


Fig. 67.—*Agrilus sinuatus*. After Division of Entomology, U. S. Department of Agriculture.

and the shoots which come up in July can not be infested. (Of course in our state we should wait at least fourteen days longer with this operation). The best results will be obtained by combining both methods. Cutting the new shoots causes the death of the young larvæ, which are unable to subsist on dead wood, and being footless, they are unable to migrate to new stalks."

Another species of *Agrilus* (*A. sinuatus*), imported from Europe within recent years, is very destructive in the eastern United States; its larva feeds between the bark and wood of pear-trees, making immensely long zig-zag galleries, and in this manner girdling and killing the tree. It differs in one remarkable respect from our destructive species in that it remains two years in the larval state. Although not found in Minnesota, the peculiar work of this injurious insect is illustrated (Fig. 67), so that it may be recognized in case our orchards should ever abound

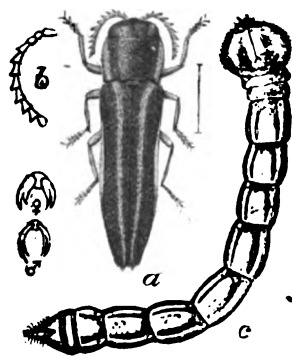


Fig. 68.—*Agrilus bilineatus*, Webb. After Division of Entomology, U. S. Department of Agriculture.

in such luscious fruit as pears. Fig. 68 illustrates still another species (*A. bilineatus* Webb.), which is not rarely found in Minnesota.

After describing such destructive beetles as those mentioned above, it is a pleasure to be able to say a good word for the insects that form the next families.

FAMILY LAMPYRIDAE.

(*Fire-flies and Soldier-beetles*).

It is scarcely necessary to describe fire-flies, as they are so well known, at least in their adult or winged state. Children living in the country have seen these beautiful objects flying over low places, such as marshes and wet meadows, or have observed them in the bushes growing along streams, ponds or lakes; they have seen the flashes produced by them along the borders of forests, or in the orchards nearer by. But children in the large cities have no opportunity to admire such wonderful phenomena, excepting, perhaps, in the larger parks. The flashes of light are given off at regular intervals, both during flight and when at rest in the grass. In some cases both male and female insects are luminous; in others it is only the one sex, and in still other instances, as in the so-called "glow-worm," the female is wingless.

When we look more carefully at these nocturnal beetles, we find that the terminal segments of the abdomen are of a bright sulphur-yellow color on the under side, which, at the will of the insects, glow with a phosphorescent light of considerable power. Different species have such luminous spots arranged in various ways, and some lack them altogether. The beetles are of a soft texture, usually slender, somewhat flattened above.



Fig. 69.—Fire Flies. After Brehm.

with a more or less retracted head. The prothorax is expanded in a thin projecting margin, which in some cases almost entirely covers the head. The peculiar power of emitting light serves two useful purposes: it is no doubt a great protection to the beetles, and it brings together the sexes. As a protection it only fails in the case of bull-frogs, which gobble up such insects in spite of the fire, which is, however, of a cold nature. In fact such frogs can be readily attracted and caught by using fire-flies as a bait. The larvæ of fire-flies burrow in the earth, and some of them are slightly luminous; they feed upon the soft bodies of other insects, upon snails, and upon other similar food. A number of such insects are illustrated in Fig. 69.

Other members of this family of beetles, which are diurnal in their habits, are called "Soldier-beetles" (Fig. 70). They are

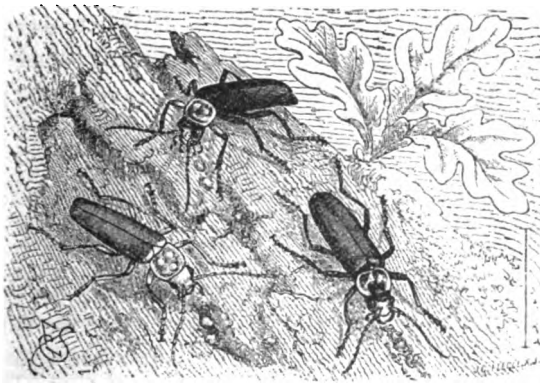


Fig. 70.—Soldier-Beetles.—After Brehm.

also soft, and frequently quite gayly colored. They are found upon flowers, where they feed upon pollen or nectar, being enabled to do so by the possession of a fleshy filament attached to each maxilla. Both fire-flies and soldier-beetles eat insects, sometimes even very large ones. The writer has in his possession a common Lightning Bug, (*Photinus pyralis* Linn.), which was found in the act of eating a beetle of equal bulk. But the bene-

fit to owners of fruit-producing plants is derived from the food-habits of the larvæ of such insects. The larvæ of the "*Two-lined Soldier-beetle* (*Telephorus bilineatus* Say), are very common, and may be seen late in fall running over sidewalks, evidently in search of winter quarters. These small, very dark brown and velvety beings, narrowed at each end, with the edges



Fig. 71.—*Telephorus bilineatus*, Say. After Riley.

of the segments quite prominently marked, are very beneficial in our orchards, and devour immense numbers of such destructive beings as the larvæ of the plum-curculios, when these enter the ground to pupate. The fat worms of the codling-moths are also to their taste; in fact they are very ravenous, and destroy many noxious insects. The larva of this insect is shown in Fig. 71.

FAMILY CLERIDÆ.

(*Checkered-beetles*).

A large number of beetles are included in this family. Most of them are carnivorous, but a few eat dried skins, decaying meat and similar substances. The adults are found on flowers and on the trunks of trees, running about rapidly, somewhat resembling brightly colored ants (Figs. 72 and 73). Some, if



Fig. 72.—*Clerus spec.* After Brehm.



Fig. 73.—*Trichodes spec.* After Brehm.

not most of them, are beautifully marked with strongly contrasting colors, for which reason Prof. Comstock calls them "Checkered Beetles" in his valuable book entitled "Manual for the Study of Insects." Some are decidedly ant-like, the prothorax in this case being narrower than the wing-covers, and slightly narrower than the head. These insects have rather long legs, the antennæ are almost knob-like; their bodies are more or less cylindrical, with a firm texture. Many species are quite hairy, others almost smooth.

The larvæ are usually carnivorous, and are most frequently found in the burrows of wood-boring insects, chiefly in those that live in sap-wood; others are found in the nests of bees, and still others feed on dead animal matter. The slender larvæ possess short legs and a somewhat prominent and pointed head. They are extremely useful in keeping in check such destructive

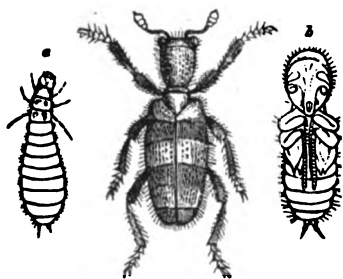


Fig. 74.—*Trichodes apivorus*, Germ.; a, larva; b, pupa. All enlarged. After Riley.

beetles as bark-beetles and other borers, and for this reason deserve our consideration. Another species of these beetles is shown in Fig. 74; it is an insect that can not be called beneficial, as it is found as larva in nests of bees, where it feeds upon their young, upon honey, and stored pollen. It is not very common in Minnesota, and is easily recognized by the brilliant red-banded wing-covers.

Some of these beetles are exceedingly numerous in the pine regions of our state, where they do much good by eating the numerous bark-insects so destructive to evergreen trees.

Another well-known beetle belongs here. It is frequently called the "Red-legged Ham-beetle," (*Necrobia rufipes*). This cosmopolitan insect is steel blue, with red legs, and is clothed with fine hair. Its normal food is dead animal matter, for which reason they are exceedingly numerous about glue-factories and slaughter-houses. If they confined their attacks strictly to such things, they could be called useful, notwithstanding

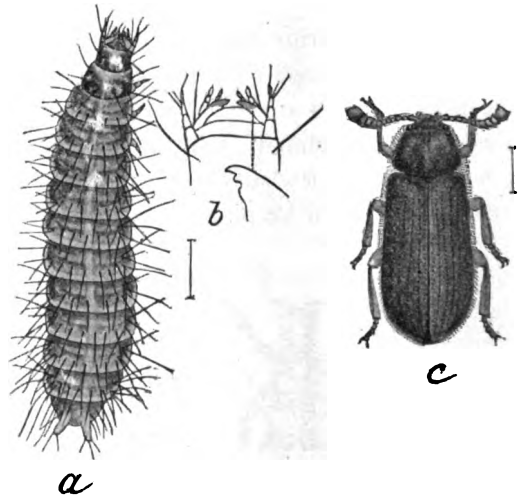


Fig. 75.—*Necrobia rufipes*, Fab.; a, larva; b, head of same; c, beetle. After Division of Entomology, U. S. Department of Agriculture.

ing what the owners of glue-factories might say, but they have learned from experience that smoked ham is much more palatable, and for the reason of obtaining this food the beetles are found in great numbers about the smoke-houses and pantries. The illustration, (Fig. 75) shows the two stages of this insect, which sometimes causes considerable losses, not so much on account of what it eats as of what it

FAMILY MALACHIIDAE.

The beetles composing this family are all small, some very small; they resemble lightning-beetles in having soft but leathery wing-covers, but are very much shorter and

especially towards the end of the elytra, where the abdomen is very broad. The antennæ are also short, a little enlarged at the tip, and in many species the males have them curiously knotted. Upon the sides of their body they possess soft and orange-colored organs, which become plainly visible if the beetles are taken up with the fingers, as in such a case these vesicles are said to exhale strong odors, offensive to cannibal insects, hence they may be considered as organs of defense.

Members of this family are frequently seen in the flowers of



Fig. 76.—*Malachius marginicollis*. Greatly enlarged. After Smith.

fruit-producing plants; they feed also on other insects and their eggs. Others have been found in the burrows made by bark-beetles. To show how such beetles look an illustration of a *Malachius* is given in Fig. 76.

FAMILY PTINIDAE.

(*Death-watch; Cigarette-beetles*).

This family is composed of rather small insects, rarely exceeding a quarter of an inch in length; the family as such is not easily defined, as it contains an aggregation of very odd-looking forms. As a rather general character they have a more or less cylindrical, firm body, solid wing-covers, and a head that can be retracted. Some are possum-like in their method of mimicking death, and they do this so thoroughly well that it is almost

impossible to make them move again. In many cases both legs and feelers fit in grooves, and the entire insect appears to be destitute of such useful organs. As various as are the forms of such beetles, just so various are their food-habits. Yet the majority of the adults and larvæ feed on dried animal or vegetable matter. Some, however, attack green vegetation. Prof. Comstock has bred large numbers of one species from the covers of an old book, a copy of Dante's Divine Comedy, printed in 1536. He does not state whether the insects also consumed the text as greedily as the covers! A description of some of these beetles will show the range of their habits.

THE DEATH-WATCH (*Sitodrepa panicea* Linn.), named so from the ticking frequently made when it is working in wood,

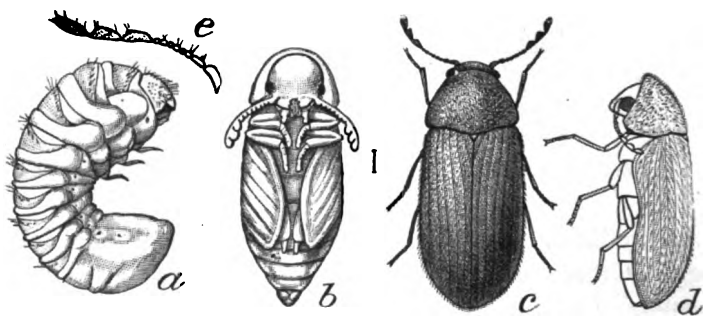


Fig. 76½.—*Sitodrepa panicea*, Linn. After Division of Entomology, U. S. Department of Agriculture.

which becomes quite audible during the night when other sounds have ceased, has given rise to many superstitions, and ignorant people consider it as a warning of approaching death. The illustration (Fig. 76½), shows this terrible being to be rather small, and certainly not very alarming. It is a bad insect, however, in other ways; and our soldiers can tell many a story of ship-biscuits enlivened by the presence of their larvæ. In fact the writer has seen biscuits thus infested that contained as much animal as vegetable matter.

THE CIGARETTE-BEETLE (*Lasioderma serricorne* Fab.), is a great lover of the weed in all its forms, and neither chewing nor

smoking tobacco is left undisturbed if it can not have cigars or cigarettes. It is very destructive to all kinds of tobacco, and is a serious trouble to the manufacturers of such ware. Still, even if more cigarettes were spoiled the general loss to sensible peo-

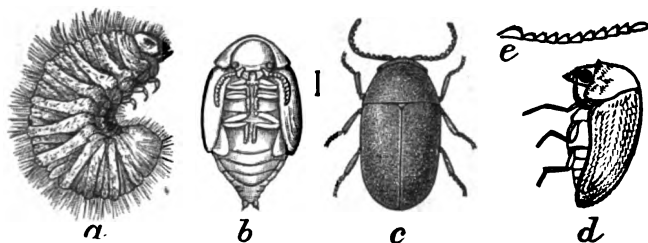


Fig. 76 1/2.—*Lasioderma serricornes*, Fab. After Division of Entomology, U. S. Department of Entomology.

le would not be very important. But there are other members of this family that deserve the close attention of fruit-growers. The cigarette-beetle is illustrated in Fig. 76 1/3.

THE APPLE-TWIG BORER

(*Amphicerus bicaudatus* Say).

This beetle is cylindrical, about one-third of an inch in length, of a dark chestnut-brown color above and black beneath. By consulting the illustration, (Fig. 77), it will be seen that its thorax is roughened in front with minute elevated points, and in the males is furnished with two little horns; this sex has also two small thorn-like projections at the extremities of the wing-covers. This beetle bores into small apple-twigs in early spring, entering close to a bud, and making a channel several inches in length, apparently to obtain both food and shelter; sometimes the vines of grapes are invaded in similar places, and are killed in consequence. Twigs of pears and cherries are also used for this purpose.

Both sexes make such tunnels, and they are occasionally found in them during the middle of winter as well as in summer; they are usually found in the tunnels with the head downwards. In this manner they sometimes work during the sum-

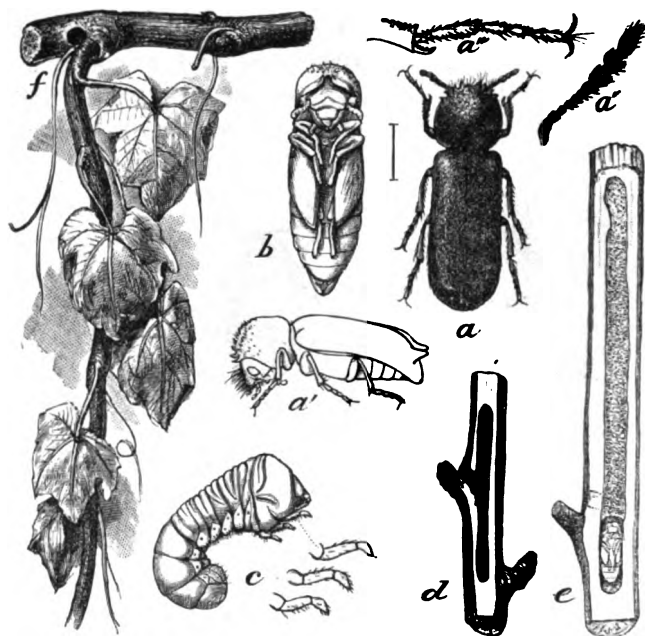


Fig. 77.—*Amphilecerus bicaudatus*, Say. After Division of Entomology, U. S. Department of Agriculture.

mer months, and cause the invaded twigs to die; as a general rule, however, the beetles leave their burrows during the summer. They now deposit their eggs in the dead or dying roots of the "greenbrier" (*Smilax spec.*), or in the dead shoots of the grape.

The larvæ, well illustrated in the figure, as well as the pupæ, remain in such places until the full-fledged beetle is formed. The insects are not common enough to cause serious damage. Twigs containing their burrows should be promptly removed and burned, and no greenbriers, a bad weed at the best, should be permitted to grow near orchards. Wild grape-vines, if harboring such beetles in larger numbers, should also be removed.

THE RED-SHOULDERED SINOXYLON.

(*Sinoxylon basilare* Say).

This beetle, closely related to the one just mentioned, is found in our state, but is rather uncommon. It is about one-

fifth of an inch long, black, with a large reddish spot at the base of each wing-cover, as indicated in the illustration (Fig. 78). The thorax is also furnished with elevated points and short spines in front; the wing-covers are roughened with dots, and appear to be cut off obliquely behind; the outer edge of this declivity is furnished with three teeth on each side.

The larva bores into the stems of grape-vines, and sometimes into the twigs of apple and peach. It is a much wrinkled grub, yellowish-white, with swollen anterior segments, three pairs of short legs, a small head, and an arched body. The pupa is formed inside the burrow, and is of a pale-yellowish color.

The only remedy is to remove and burn infested canes and

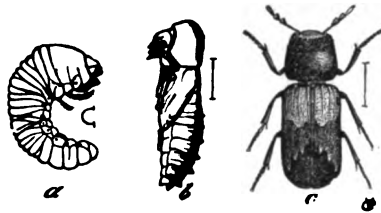


Fig. 78.—*Sinoxylon basillare* Say. After Riley.

twigs. Several other related beetles have been reported as being injurious to orchards, but none of them are found in our state. Others, which do not cause any injury to the plants themselves, but to the posts to which the canes of raspberries, grapes, and other plants are tied, might be mentioned, as fruit-growers are sometimes molested by them.

Beetles belonging to the genera of *Bostrychus* and *Lyctus* destroy old and dry wood. The latter especially are sometimes very abundant, and their presence may be recognized by the large amount of exceedingly fine dust that gathers at the base of such posts.

The beetles themselves are very seldom seen in large numbers on the infested posts, but if we cut open one of them apparently still solid, we find it entirely honey-combed inside. Even such exceedingly dry and hard substances as hoe-handles made

of hickory, if left undisturbed for a long time in have been known to be entirely destroyed by its character.

D. LEAF-HORNS.

(*Lamellicornia*).

Leaf-horns contain only two families of beetles; numbers but a few species of remarkable forms, very large number; some of them are scavengers, or feeders. This second family is one of great extent large and showy insects belong to it. But, notwithstanding their different forms and food habits, all resemble each other in the possession of feelers which terminate in a knob of three or more leaf-like blades, which, at the will of the insect, can be folded up like the pages of a book.

FAMILY LUCANIDAE.

(*Stag, or Pinching-beetles*).

Stag-beetles are well named on account of the males of which have immensely large mandibles branched like the antlers of a stag. Their chief characteristic, however, is the form of their antennæ. These are terminated, i. e., the tips of the feelers are furnished with several sharp projections on one side, like the teeth of a comb; they are also bent and elbowed in the middle. These projections composing the club can not be closed together as the next family. (Compare Fig. 9).

The adult beetles feed upon the sap of bruised trees; they can secure this food by means of brushes located on their heads and lips. By knowing this food-habit many can be prevented from purposely bruising such plants, as young oaks, and hickories. The eggs are large, globular, white objects deposited in the crevices of the bark near the roots.

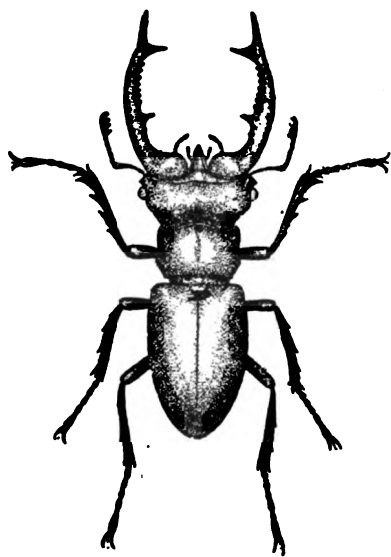


Fig. 79.—*Lucanus elaphus*, Fab. After Fuchs.

semble "white grubs," only they do not eat the roots of plants, but bore into the solid wood of the trunks and roots of trees, reducing it to coarse sawdust. In most cases the larva requires a number of years to reach its full size.

Stag-beetles are of but little economic importance, but as their forms are very striking, they are of much popular interest. The illustration, Fig. 79, shows the male of the large stag-beetle (*Lucanus elaphus* Fab.), which does not seem to be found in Minnesota, and Fig. 80 that of (*L. dama*, Thunb.), which is very common in our state.

THE STAG-BEETLE.

(*Lucanus dama* Thunb.).

The male of this large beetle has the upper jaws or mandibles largely developed; they are curved like a sickle, and possess a small tooth near the middle of the inner margin; the female has smaller jaws, also toothed. Large specimens measure about two

inches in length; they are of a deep mahogany-brown color, the legs being very much lighter. The broad head of the male is smooth, that of the female narrower and rough. The males fly during the months of July and August, and are very strong flyers, so that they can be heard buzzing about during the evening or night. They are attracted by light, and enter our houses, where they greatly scare some persons. They never bite, however, unless forced to do so by being roughly handled. The females are more retiring in their habits, and are not often found, and if seen at all, it is usually upon the trunk of some bleeding tree.

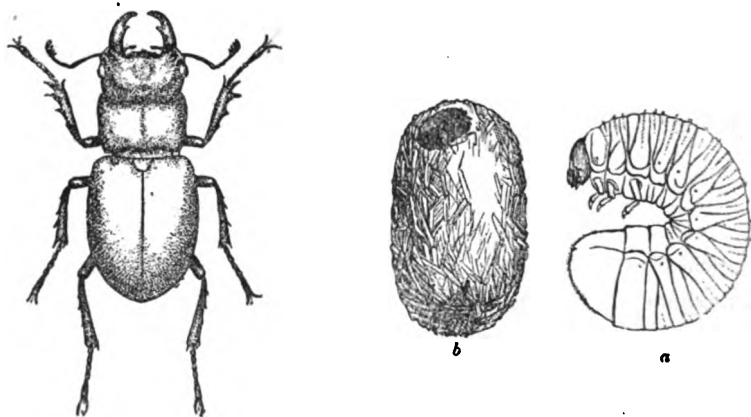


Fig. 80.—*Lucans dama*, Thunb. Adult; a, larva; b, cocoon. After Fuchs and Harris.

The large larva of this beetle is found in the decaying wood of many different kinds of trees, such as oak, apple, cherry, or willow. From the very fact that these larvæ are only found in old and decaying trees we can feel certain that they cause but slight, if any damage. Larva and cocoon are shown in Fig. 80.

A smaller beetle belonging to this family, the *Platycerus quercus* Web., is sometimes injurious, because it devours the buds of pear trees. It is also found in Minnesota, but mostly in the decaying wood of old oak logs and stumps. It is a rather peculiar beetle, nearly half an inch in length, with very large jaws in the

male sex, but only small ones in that of the female; it has ribbed wing-covers, black, with a greenish cast. In Illinois it matures about the time at which buds of pear trees unfold, and in such buds the adult beetle feeds for many days, completely eating out the buds and the ends of the new shoots.

FAMILY SCARABAEIDAE.

(*Lamellicorn-beetles*).

This is a very large family, including beetles with a very wide range of variation in size, form, and habits. Most of them are short, stout beetles like the Tumble-bug or June-bug. All possess an antennal club, the leaves of which can be closed together or spread out at will, like a fan, exposing the numerous sensory pits with which they are densely covered.

We can divide the family into two well-marked groups, the *Scavengers* and the *Leaf-chafers*.

The *Scavengers* are of little interest to fruit-growers, but a few forms will be described to give an idea of their form and habits.

The Tumble-bugs are perhaps best known on account of their peculiar habit of forming round balls of dung, which they roll long distances. The two sexes most frequently work together, and after having rounded and compressed the ball by rolling it in dusty places, till it is hard and compact, thus preventing

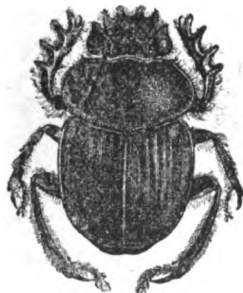


Fig. 82.—*Iteuchus sacer*. After Brehm.

rapid drying of the enclosed moist material, they finally bury it in the ground. The male now leaves, and the female eats out a cavity in the ball, in which she deposits an enormously large and soft egg; this done, she again closes the cavity by plastering the removed portion of the dung over it. The egg soon hatches, and in a very short time the larva is fully grown, and transforms to a pupa. The whole period of growth takes less than fourteen days. The illustration (Fig. 81, plate 1) shows the ball, egg and adults of one of these beetles (*Canthon laevis* Drury).

Tumble-bugs were well known to the ancient Egyptians, who held one species of them, the *Sacred Beetle* (Fig. 82), in high veneration. They considered it a symbol of strength and resurrection, and for this reason stone imitations of the beetles were placed in the tombs with their dead. "The ball, which the beetles were supposed to roll from sunrise to sunset, represented the earth; the beetle itself personified the sun, because of the sharp projections on its head, which extended out like the rays of light; while the

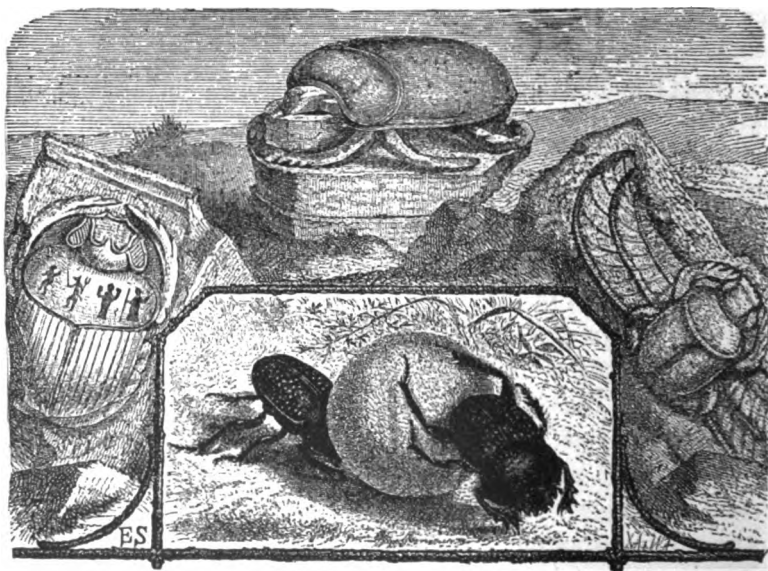


Fig. 83.—*Ateuchus variolosus*. rolling balls. Egyptian sculptures of Sacred beetle. After Brehm.

thirty segments of its six tarsi represented the days of the month. All individuals of this species were thought to be males, and a race of males symbolized a race of warriors. The latter superstition was carried over to Rome, and the Roman warriors wore images of the sacred beetle in rings." The illustration, (Fig 83), shows the familiar action of the two beetles, as well as some sculptures and inscriptions. None of such scavengers are injurious in our country, although exceptions occur in others, where members of scavenger beetles destroy roots of the grape vine.

Other scavenger beetles, like the *Copris carolina* Linn., illustrated in Fig. 84, do not roll balls, but they make holes close to or

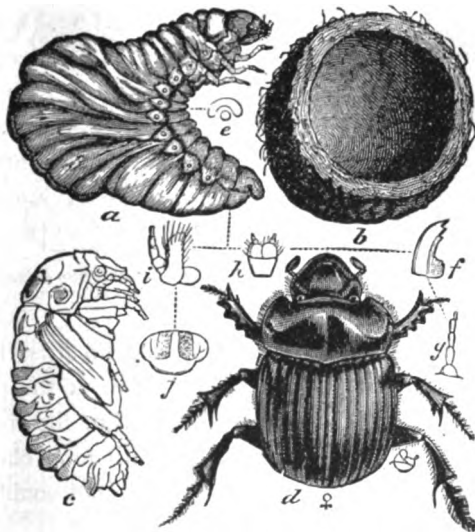


Fig. 84.—*Copris carolina*, Linn.; a, larva; b, ball; c, pupa; d, adult female. After Riley.

under manure, especially that of cows, and fill the holes compactly with this substance as a store of food for their larvæ, which hatch from eggs deposited in the lowest parts of such burrows, one in each. Some allied beetles are most beautiful objects, of metallic colors, and beautified in the most remarkable manner with all sorts of odd horns found upon head or thorax.

It has, however, been stated upon very good authority that the common black *Aphodius* (*A. granarius* Linn.), illustrated in Fig. 85, has the bad habit of eating into sprouting seeds of corn. At all events some species of this genus very often attract the attention of farmers, as immense numbers of them swarm early in spring, and again late in autumn, over country roads, and especially over such roads that have been frequented by horses and cows. Here the beetles enjoy their last meals before entering the ground to pass the winter. The illustration (Fig. 86) shows an adult beetle and its larva.



Fig. 85.—*Aphodius granarius*, Linn.
Greatly enlarged. After Forbes.



Fig. 86.—*Aphodius fossor*, Linn., and
larva. After Brehm.

The *Leaf-chafers*, or *Herbivorous Lamellicorns*, feed upon leaves of trees in their adult state, or they devour the pollen and petals of flowers. They are distinguished from the majority of scavengers by having more slender legs, with long claws which enable them to grasp their food firmly, but do not enable them to dig into the ground. Some of them can, however, do so, but not so easily as their relatives with filthier habits. As a general rule the tip of their abdomen projects beyond the wing-covers, and is not shortened or cut off squarely. Since the adults also feed upon vegetable matter they are in some cases as destructive as their larvæ, only, however, for a much shorter period. The larvæ feed either in rotten wood, when they are harmless, or they eat the roots of grasses and other plants. Such larvæ, well known as "white grubs," are thick, fleshy beings, much wrinkled, with a

body so much curved that they can only crawl about with great difficulty if placed upon the surface of the soil. They possess large horny heads, and long, sprawling legs. The posterior segment of the abdomen is in many species thicker than the remainder, and appears dark, being filled with a large amount of dirt and other waste matter. In their burrows such larvæ can, however, move quite rapidly; they do so by lying on their backs, which are usually protected by a cushion of short hairs; their legs are mainly used to grasp the food overhead.

Many groups of these beetles are familiar, some of them well known by the common name of "May-beetles," "Dor-beetles," "June-bugs," "Rose-beetles," "Goldsmith-beetles," "Rhinoceros-beetles," "Flower-beetles," and others. Only those that are injurious to the fruit-grower, or are otherwise of special interest, will be described more in detail.

We have in Minnesota a number of small lamellicorn beetles that are sometimes destructive to the flowers of fruit-producing plants. They are not numerous enough to cause marked injury, at least not unless many of them are at work on the same tree or cane. They belong to two genera: *Hoplia*, and *Dichelonycha*. The former are robust, oval insects, injurious to apples and plums, of which they destroy the entire flowers. *Hoplia modesta* Hald, an oval shaped, brown beetle, with a metallic white pubescence upon the pointed and projecting posterior segments of the abdomen, and with long legs, well adapted to anchor it in flowers, is the most common one of such small enemies. It measures about one-quarter of an inch in length, and is shown in Fig. 87, Plate I.

Dichelonycha elongata Fab., and *D. subvittata* Lec., also possess a similar bad habit. Both beetles resemble each other in general appearance, but instead of being oval in shape they are quite elongated, measuring almost half an inch in length. Their general color is also brown, but they possess in addition a decidedly metallic lustre, varying from all shades of dark blue to bluish-green or green. In case of necessity these beetles should be gathered and killed. This is easily done upon low plants, where they can readily be seen, but it is almost impossible when

they are found upon trees. But as they are only active during the warmer portions of the day, resting or sleeping at other times, in beautiful cradles of white petals, protected by a cover composed of yellow grains of pollen, they are easily shaken from the inverted umbrella, or in extreme cases into a large sheet spread under the tree. However, a simple shaking avails but little; the trees must be jarred by a sharp blow made with a mallet or a stick with cloth, to prevent injury to the trunks. Both species are shown in Fig. 87, Plate I.

THE ROSE-CHAFER, OR ROSE-BUG.

(*Macrodactylus subspinosus* Fab.).

This destructive beetle is only too well known in some portions of the United States, but happily it is of rare occurrence in Minnesota, at least at the present time. It is found in June and July, at the time when grapes and roses are in full bloom; it feeds on the dainty morsels as these highly scented flowers in preference to anything else, but in their absence it is satisfied with leaves.

Prof. Smith, who had ample opportunity in New York to study this beetle, which is illustrated in Fig. 89, writes as follows:

"Occasionally, for a number of years, the insects attain an ever increasing abundance, until the swarms are so great that they ruin not only vineyards, but orchards and garden plants of almost every kind of fruit and flower. In the presence of these swarms we are almost helpless, and insecticides are of no use. No contact poison kills them, and the arsenites and stomach poisons act too slowly, as two or three days are required to ruin a vineyard. Lest this will seem strange, I will state that I have seen on hundreds of acres of vineyard every vine covered with multitudes, and every bunch of blossoms harbored from thousands or even more beetles. I have counted over twenty on a single vine, and a full-blown rose may bear as many as thirty or even more. We are reduced to actually collecting the specimens from the vines by means of funnel or umbrella-shaped collectors."

to the method of cultivation in use. They drop readily when the vines are jarred, and the collector should be so made as to roll them into the center and into an attached pail containing kerosene. This must be done not only daily, but continuously for several days until the flight is over or the grapes have set, for well-set grapes are rarely eaten. Fortunately, a period of abnormal increase seems to be followed by a period of decrease, though the length of the periods have not been ascertained. The

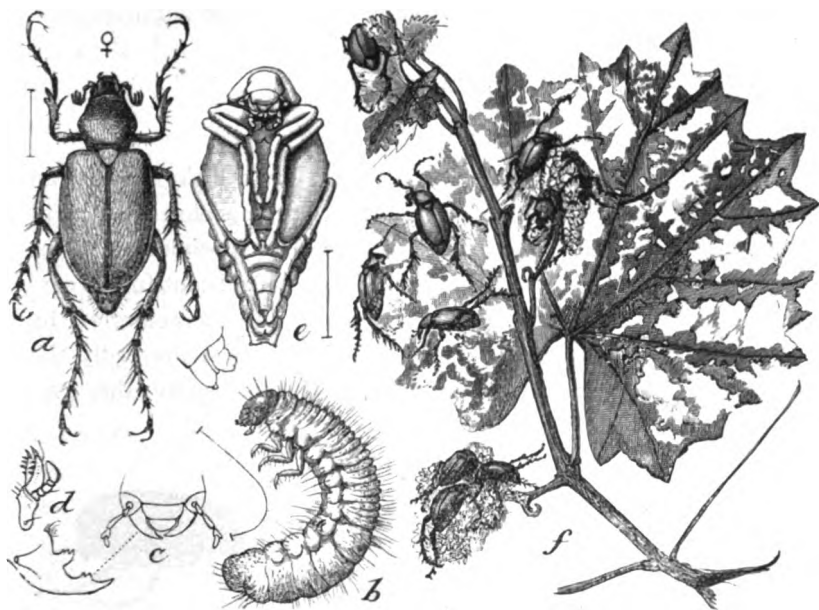


Fig. 89.—*Macrodactylus subspinosus*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

larvæ feed in light land on the roots of various plants, but principally on grass. They pupate in spring, shortly before they change to the adult condition, and by ploughing infested sod at this time a large proportion can be destroyed. When only moderate numbers occur, lime often serves to protect the plants, or, better, the Bordeaux mixture, which is distasteful to them."

As may be seen by the illustration this ochreous yellow

beetle, slender in form, possesses long and very spiny legs, which are so sharp that birds refuse to eat their owners. Even hens will ogle such food, and express their disapproval by letting it severely alone, no doubt having learned from experience that such morsels will not slide down very readily. When stating that the beetle is of an ochreous-yellow color, this statement should be amended by saying that this color is produced by dense and even scales of that color, which rub off very readily, exposing the black colors of the wing-covers and body. In this case we have an insect which is both destructive in its larval and adult stage.

THE SILKEN SERICA.

(*Serica sericea* Ill.).

This small beetle, also oval in shape, but a little larger than the *Hoplia* mentioned before, is of a brown color when still young, but becomes quite dark with age. Specimens not injured by having their surface rubbed are truly beautiful in certain lights, showing in such positions almost all the colors of the spectrum upon a silky background. This is most markedly the case near the sides. But notwithstanding this beauty, they can

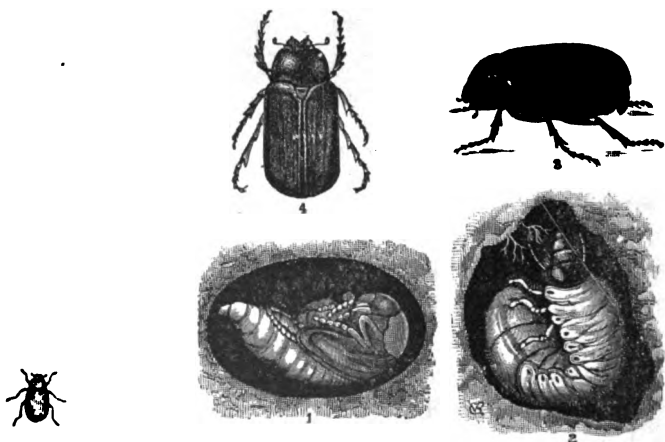


Fig. 90. *Serica tricolor*, Say.—
After Saunders.

Fig. 91.—*Lachnosterna fusca*, Froehl.—After Division of Entomology, U. S. Department of Agriculture.

become destructive by eating flowers and leaves of our fruit-producing plants. *Serica iricolor* Say is shown in Fig. 90.

This species, as well as two others, the bluish-black *S. iricolor* Say, which has a hairy thorax, and the uniform mahogany-brown *S. vespertina* Gyll., are fairly abundant in Minnesota, and can be kept in check by beating them from the plants into inverted umbrellas, where they can be gathered and destroyed. Their larvæ are not known, but very likely they live upon roots in the ground like the larvæ of related beetles. Other species of this genus are destructive in California. Fig. 87, Plate I, shows *S. iricolor* Say, and *S. vespertina* Gyll.

MAY-BEETLES, OR JUNE-BUGS.

(*Lachnosterna spec.*).

Prof. Saunders, in the book already mentioned, gives a condensed account of the life-history of these beetles in the following words: "Every one must be familiar with the May-beetle,---or May-bug, as it is commonly called,---a buzzing beetle, with a slow but wild and erratic flight, which comes thumping against the windows of lighted rooms in the evenings in May and early June, and, where the windows are open, dashes in without a moment's consideration, bumping against walls, ceiling, and articles of furniture, occasionally dropping to the floor, then suddenly rising again. It sometimes lands uninvited on one's face or neck, or, worse still, on one's head, where its sharp claws become entangled in the hair in a most unpleasant manner. It is a thick-bodied, chestnut-brown or blackish beetle, (Fig. 91), from eight to nine-tenth of an inch in length. Its head and thorax are punctuated with small indentations; the wing-covers, though glossy and shining, are roughened with shallow, indented points, and upon each there are two or three slightly elevated lines running lengthwise. Its legs are tawny yellowish, and the breast is covered with pale-yellowish hairs; the under surface is paler than the upper. During the day the beetles remain in repose, but are active at night, when they congregate upon cherry, plum, and other trees, devouring the leaves, occasionally, when very



Fig. 92.—June beetles at night. After Brehm.

numerous, entirely stripping the trees of foliage (F). Their strong jaws are well adapted for cutting their food. Their notched or double claws support them securely on the foliage.

"The female is said to deposit her eggs between the blades of grass, enclosed in a ball of earth; they are white, transparent, and spherical, and about one-twelfth of an inch in diameter. When hatched, the small white grubs begin at once to feed on the rootlets of plants; they are several years in reaching maturity, and hence larvæ of different sizes are usually found on the ground at the same time. When full-grown, they are almost as thick as a man's little finger; they are soft and pliable, have a horny head of a brownish color, and six legs; the posterior part of the body is usually curved under, as shown in the

tration. This larva is generally known as the "white grub," and is very injurious to strawberries, devouring the roots and destroying the plants; it feeds also upon the roots of grass and other plants, and when very numerous it so injures pasture-lands and lawns that large portions of the turf can be lifted with the hand and rolled over like a piece of carpet, so completely are the roots devoured. When cold weather approaches, the grub buries itself in the ground deep enough to be beyond the reach of frost, and there remains until the following spring.*

"When ready for its next change, the larva forms a cavity in the ground, by turning itself round and round and pressing the earth until it moulds a cell of suitable form and size, which it lines with a glutinous secretion, so that the cell may better retain its form, and within this it changes at first to a pupa, and finally produces the perfect beetle.

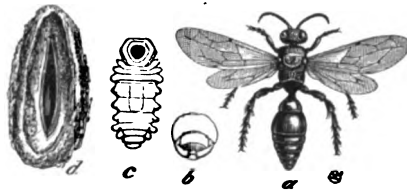


Fig. 93.—*Typhla inornata*, Say. After Riley.

"Remedies: It is very difficult to reach the larvæ underground with any remedy other than digging for them, and destroying them. Hogs are very fond of them, and, when turned into places where the grubs are abundant, will root up the ground and devour them in immense quantities. They are likewise eaten by domestic fowls and insectivorous birds; crows especially are so partial to them that they will often be seen following the plough, so as to pick out these choice morsels from the freshly-turned furrow. An insect parasite, the unadorned Tiphia, *Tiphia inornata* Say, is also actively engaged in destroying the white grub.

*The writer has long ago come to the conclusion that insects do not enter the ground simply to escape the rigors of winter. If they had to do so, they would be forced in Minnesota to go to the same depth as water pipes, which have to be laid from six to eight feet to prevent freezing!

Frequently, when digging the ground, a pale-brown, egg-shaped cocoon is turned up (Fig. 93*d*) ; within this, when fresh, is found a whitish grub, represented at 92*c*, which, during its growth, has fed upon the larva of the May beetle. Within its snug enclosure it soon changes to a pupa, and finally assumes its perfect form, as shown at *a* in the figure. The fly is black, sometimes a faint bluish tint, with dusky wings, and the body more or less covered with pale-yellow hairs, which are longest on the under side.

"A curious whitish fungus sometimes attacks this larva and destroys it, growing out at the sides of the head ; the plant-like sprout rapidly increases in size, often attaining a length of three or four inches, when it presents the appearance of a mushroom. 94. A very large number frequently die from this cause. Gardens infested with the beetles should be shaken early in the spring, when the insects will fall, and may be collected on sheets. They are killed by being thrown into scalding water. Besides the poplars and plum, these insects feed on the Lombardy poplar and the oaks. On account of the length of time the larva takes to mature, the beetles are not often abundant during two successive seasons."

At the time Prof. Saunders wrote the above excellent description the numerous species of the genus *Lachnosternus* were not yet well understood, but since that time a number of entomologists have not alone studied the adult forms, which include more than sixty species, but also their larvæ, the "grubs," have been studied. Hence the description given applies not to a single species, described as *L. fusca* Fabricius, but to a whole group of very similar kinds. Such studies have, however, given us newer and better methods to combat the injuries caused by such insects in the larval condition ; to fight the grubs successfully is still an unsolved problem.

In Minnesota we have a number of species varying in color, and structural details ; some are small and yellowish, covered with long hairs, others are dark and smooth ; some appear at the time of year that gives such beetles the popular name of "May beetles."



Fig. 94.—May beetle fungus. After Riley.



Fig. 95.—*Lachnosterna tristis*, Fab.

May or June-beetles, others occur much later in the season, being found as late as the end of September, or even early October. However, none of these later flying beetles are very numerous.

The smallest of our species is the *L. tristis* Fab. (Fig. 95). It is of a light yellowish-brown or ochre-yellow color, densely covered with long and fine hairs; this hair is most prominent upon the thorax, and for this reason the beetle is frequently called the "hairy-necked May-beetle." It is not only the smallest species, but also the earliest to appear, and our oaks suffer very greatly at the time in which the leaves unfold, and it is not an uncommon occurrence to find the tree entirely bare of leaves after repeated nocturnal visits of these beetles. If they are at all numerous the observer can detect their presence by the peculiar sounds produced by them; it seems as though a large swarm of bees was employed in the tree. Such beetles, like many of their larger relatives, are frequently thrown out of the ground early in spring by the spade.

Our most common larger species are the members of the *fusca* group, and the *L. rugosa* Melsh. (Fig. 96), which is distinguished by shining, but at the same time very rugose wing-covers. It is common everywhere, not alone in the wooded regions of the state, but in the open prairies as well.

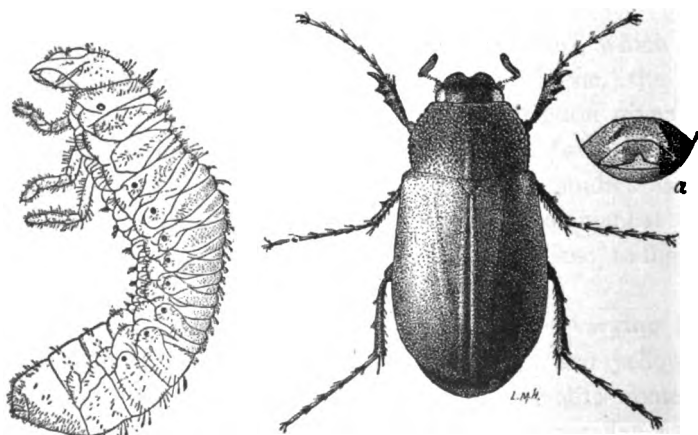


Fig. 96.—*Lachnosterna rugosa*, Melsh. After Forbes.

Other species are covered with a very fine pubescence, almost entirely hiding the wing-covers; others have longer hairs arranged in parallel rows upon the elytra; but all have such a familiar look, that the illustrations given will convey a good idea of the appearance of nearly all.

With us the beetles emerge from the ground just at dusk, or soon afterwards, and they leave the trees long before sunrise, so that the beating of the trees even very early in the morning will secure but a very few, hence does not amount to much as a remedy. But as such insects can be attracted to light, immense



Fig. 97.—Lamp trap. After Lintner.

numbers can be captured and killed by placing under a strong light a vessel containing water with some kerosene floating on it. (Fig. 97). If we study the captured beetles, we find that in some cases only the males of some species have been caught; again we find both sexes in about equal numbers, and in some few cases mainly females are attracted. But whether the females have already deposited their eggs or not is a question, and it is also doubtful whether we do much good by so attracting them. It seems to the writer that the strong light not alone at-

tracts the beetles, but that in doing so we may aggravate the evil in some cases by bringing them to the more valuable trees planted near our houses, in which case the females are certain to deposit their eggs in our lawns.

Among the *Shining Leaf-chafers*, which resemble May-beetles in form, but are separated from them by the possession of tarsal claws of unequal size, one claw in each pair being larger than the other, (see Fig. 99), we find species of brilliant colors



Fig. 98.—*Anomala undulata* Welsh.—Enlarged. After Harris.

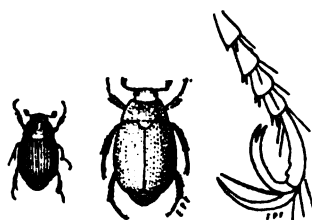


Fig. 99.—*Anomala marginata*, Fab.; *A. lucicola*, Fab., and enlarged tarsal claws. After Lintner.

and markings. This is especially true of tropical species, which contain some of the most beautiful beetles known. They possess wing-covers and bodies apparently made of gold, silver, or other metal. Most of such beetles are also of medium size; others are large, sometimes very large. But few species are found in Minnesota, and none of them are very destructive.

THE LIGHT-LOVING ANOMALA.

(*Anomala lucicola* Fab.).

This beetle feeds upon the leaves of grape and other plants. It is a robust insect, long oval in form, measuring about one-third of an inch in length. It is of a pale yellowish-brown color, the prothorax is either uniform in color, or black, margined with dull yellow; the posterior part of the head and the ventral side of the body are black, but sometimes the abdomen is brown. The beetles vary greatly in color and markings; some are almost

entirely black, and others have two broad diverging longitudinal greenish bands upon the disk of the prothorax. The beetles can be destroyed by means of Paris-green.

A little larger species of this genus is the "Two-spotted Anomala," (*A. binotata* Gyll.), which also varies considerably, but can in most cases be recognized by two larger or smaller, irregular black spots, one upon each wing-cover; head and thorax are uniformly polished black or dark-brown, always much darker than the wing-covers; the under side of the body is colored like head and thorax.

A much smaller species, the *A. minuta* Burm., is quite common in Minnesota. It varies even more than the two species already mentioned, some being entirely dark brown, others bright-yellowish brown; some possess no markings at all, others are ornamented with small spots forming one or more bands across the wing-covers; while still others have numerous dark spots, sometimes confluent, thus forming a narrow upper and broad lower band across the elytra.

Still other members of this genus occur in this state, but are more abundant further south, where they sometimes cause considerable injury to fruit-producing plants. The largest species is *A. marginata*, Fab., a beetle much larger than those already described, measuring about one-half an inch or more in length. It is also brown, but with a peculiar green luster, especially if seen from above. The darker prothorax is edged with a broad margin of yellow. It is shown in Fig. 99.

These beetles are harmless when they appear singly; but sometimes they occur like the Rose-beetle in large swarms, and in such cases they riddle the foliage of the plants to such an extent that it resembles a piece of net, and only the larger veins are left undisturbed. The larvæ live in the ground, feeding there upon the roots of plants. As they cannot be reached in such quarters we have to fight the beetles themselves, which is readily accomplished by the use of arsenical poisons, by dusting the vines with fresh air-slaked lime, or by syringing them with a solution of whale-oil soap or strong tobacco water.

The following letter, published by the late Dr. L. one of his excellent reports, will give an idea of the such beetles may give the horticulturist: "And now we *Anomala marginata*. This is the too modest name of species of May-beetle, which for "pure cussedness" can rose-bug points and come out ahead. It resembles the is about half the size and in color is metallic bluish-green creature appeared for the first time last summer in this just as the rose-bug was leaving, and promptly began doing everything that the other hadn't time to eat. While blessing the appetite of the rose-bug and the elephant combining not so formal as the former, but brings all its luggage and remains with us until fall. While the rose-bug has slipped this summer, the *A. M.* has come again in millions. eating breakfast about six days ago and hasn't knocked to get ready for lunch. Some of my vines are already foliated. I have found them to some extent on blackberry, and rose bushes, but its preference is the grape vine.

"I tried hand-picking and shaking them into a vessel of water and kerosene. I had three men working in a thirteen hundred Cynthiana vines for an entire day. In the they destroyed gallons of them. The next morning there in unbroken ranks, not a vacancy visible. I then spraying with London purple, a pound to one hundred gallons of water. If this treatment has caused them pleasantness I have yet to discover the fact. One might try to convince the Sabbatarians that there are other people in the world who have rights.

"If any of your readers having vineyards have been troubled by these pests and have succeeded in getting rid of them, I like to learn their methods. Kerosene emulsion might be a deterrent, but I fear that it would spoil the grapes for making. In the meantime, my emotions are too great for patience. I think that Job makes no mention of ever having tended with the *Anomala marginata*. I would he were here. His opinion expressed in choice Chaldaic might possibly solve the case and give me some relief.

J. L.

THE SPOTTED VINE-CHAFER.

(Pelidnota punctata Linn.).

This is a grape-vine pest in more southern and eastern states, where it devours the foliage, but is by no means a common beetle in Minnesota, hence not as destructive as elsewhere. It is a stout beetle, large specimens almost reaching an inch in length, of a clay-yellow color, with three large black dots near the margin of the elytra. These spots are very prominent in northern specimens, but are frequently very small or even absent in southern ones. The whole under side of the insect, including the legs, is black with a metallic green tint. The base of the head, between the eyes, the margin of the scutellum, and one spot on each side of the thorax are also black. The insect is nearly oval in form, with a polished surface.

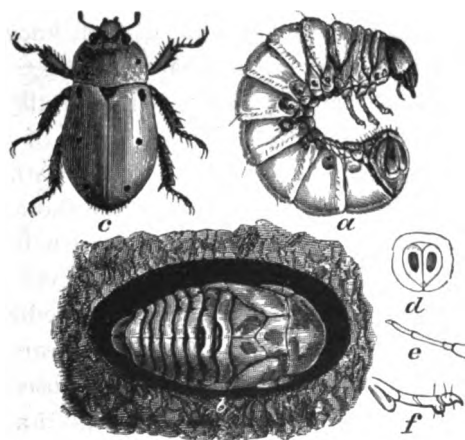


Fig. 100.—*Pelidnota punctata*, Linn. After Riley.

These beetles fly during July and August, and are only active during the day, flying from vine to vine with a heavy flight and a loud buzzing noise. Being so large and showy, they are easily detected at their work, and should be reduced in numbers by hand picking.

The female deposits her eggs in rotten wood, on which the larva feeds. The latter seems to prefer the decaying apple, pear, hickory and some other trees. When full grown it is nearly two inches in length, of the usual shape of other grubs," but not so densely covered with hairs. It has a nut-brown head and a translucent white body, of a clearer color than that of other and similar shaped larvæ; the posterior end ends in a heart-shaped swelling, short and cut off. Seen from the front it is marked as shown in the Fig. As soon as full grown the larva forms a slight cocoon of particles of the surrounding wood; in it it changes to a pupa, from which the beetle escapes about ten days afterwards.

THE GOLDSMITH-BEETLE.

(*Cotalpa lanigera* Linn.).

This is without doubt one of our most beautiful beetles, as it is rather common in our state, is well known, and is much liked by our children, whose eyes are so sharp in detecting all the strange looking or beautiful things. The beetle is about one inch long, and is broadly oval in shape. It is of a lemon color above, glistening like burnished gold, with prismatic reflections on the top of the head and on the thorax. The under side is copper-colored, and is thickly covered with white hairs, hence the name *lanigera* or wool-bearer. Even the polished upper surface is coated with an exceedingly fine layer of white in fresh specimens; this, however, soon disappears, being rubbed off. Fig. 101, Plate III, shows this beautiful insect.

Although so common it can hardly be called a very beautiful beetle. According to Saunders "this insect appears late in the season and during the month of June, and is distributed over a large area, being found in most of the Northern States and in the West, and although seldom very abundant, rarely does a season pass without some of them being seen. During the day they are inactive, and may be found clinging to the under side of the leaves of trees, often drawing together two or three leaves,

ing them with their sharp claws for the purpose of concealing themselves. At dusk they issue from their hiding places, and fly about with a buzzing sound among the branches of trees, the tender leaves of which they devour. The pear, oak, poplar, hickory, silver maple and sweet-gum all suffer more or less from their attacks. Like the common May-bug, this beautiful creature is attracted by light, and often flies into lighted rooms in summer evenings, dashing against everything it meets with, to the great alarm of nervous inmates. In some seasons they are comparatively common, and may then be readily captured by shaking the trees on which they are lodged in the daytime, when they do not attempt to fly, but fall at once to the ground.

The beetle is short lived. The female deposits her eggs in the ground at varying depths during the latter part of June, and,

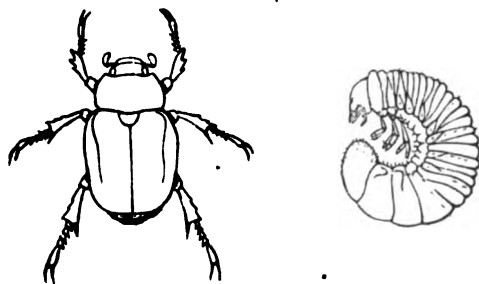


Fig. 102.—*Cota/pa lanigera*, adult and larva.—After Division of Entomology, U. S. Department of Agriculture.

having thus provided for the continuance of her species, dies. The lives of the males are of still shorter duration. The eggs are laid during the night, the whole number probably not exceeding twenty. They are very large for the size of the beetle, being nearly one-tenth of an inch in length, of a long, ovoid form, and a white, translucent appearance.

"In about three weeks the young larva is hatched; it is of a dull-white color, with a polished horny head of a yellowish-brown, feet of the same hue, and the extremity of the abdomen lead-color. The mature larva (Fig. 102) is a thick, whitish,

fleshy grub, very similar in appearance to that of the May-bug, which is familiarly known as the "white grub." It lives in the ground, and feeds on the roots of plants, and is thus sometimes very destructive to strawberry plants. It is said that the larva is three years in reaching its full growth; finally, it matures in the autumn, and late in the same season, or early in the following spring changes to a beetle."

Among the RHINOCEROS-BEETLES we have in Minnesota a number of species which do not possess a shape that is in the least like the one giving name to this group of beetles. Yet a few of them should be mentioned, as they are frequently sent to the office of the entomologist to be identified.

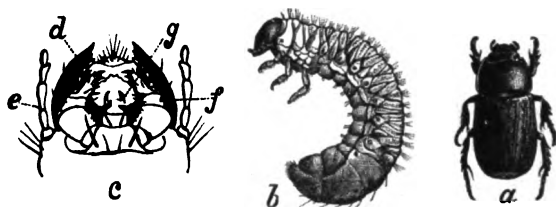


Fig. 103.—*Chalepus trachypygus*. Burm.—After Division of Entomology, U. S. Department of Agriculture.

It is well known that old manure harbors many grubs that look very much like those producing the May-beetles. Yet they are mostly of an entirely different character, as they change into black, polished beetles (Fig. 103), with faint longitudinal striæ upon their wing-covers. Such beetles have received the scientific name of *Chalepus trachypygus* Burm. The insects are harmless in Minnesota, notwithstanding their resemblance to the common white grub in the larval stage, and there is no danger in using the material, in which they thrive, upon lawns and in gardens.

Such good words can not be said about similar beetles of a dark brown color that are fairly common with us. Two species of *Ligyris* are rather common in Minnesota, and a third, the *Aphonus tridentatus* Say, is also found in some numbers in cer-

tain seasons and localities. The "Sugar-cane Beetle" (*Lygyrus rugiceps* Lec.) sometimes causes considerable injury to sugar-cane and corn in the Southern States. It is shown in Fig. 104. *L. relictus* Say is exceedingly common in many places. Its larva feeds in rotten manure, and is frequently used as bait for fish.

In British Guinea beetles similar to the *Chalepus* mentioned above were so common near the fields of sugar-cane that it was a punishment to sleep near fires started to keep away the mosquitoes, and it was frequently a question which of the two

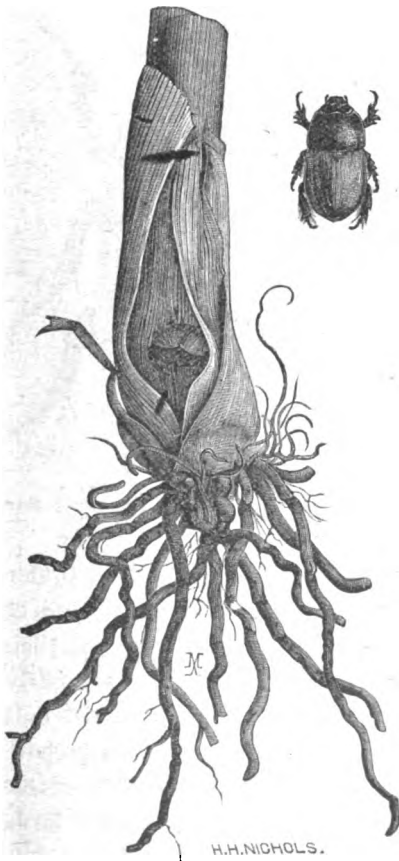


Fig. 104.—*Lygyrus rugiceps*, Lec.—After Division of Entomology, U. S. Department of Agriculture.

insects deserved the prize for being the greatest tormentor. Not that the beetles would bite, but they would crawl all over a person, and as their feet were not clad in slippers, but were shod with long nails in the form of sharp spines, their presence was far from being pleasant, especially as they were "thick as bees."

Among the members of the RHINOCEROS-BEETLES one species should be mentioned, as it is the largest of our American beetles; it is well named the *Rhinoceros-beetle*, (*Dynastes tityus* Linn.), as may be seen in the illustration (Fig. 105). The larva of this

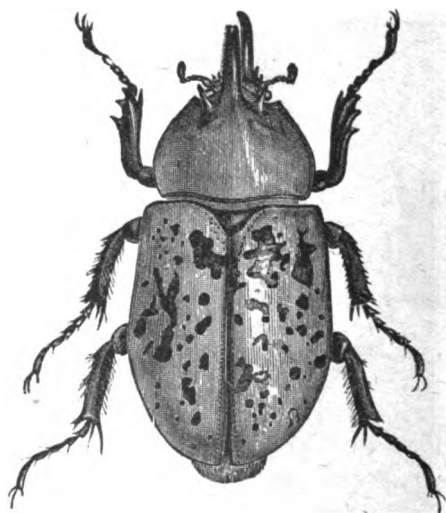


Fig. 105.—*Dynastes tityus*, Linn. After Division of Entomology. U. S. Department of Agriculture.

giant feeds in the roots of decaying trees, preferring old cherry-stumps. The ash furnishes food for several allied but smaller species, both for the adult beetles and for their larvæ. In the South, where such bad-smelling beetles are fairly common, sometimes very much so, they may be attracted by bruising willows or other plants, and there the adults congregate to lap the sap. It is only the male that possesses such horns, which are simply ornamental, and not useful, as poorly fed larvæ produce males with very short horns. Notwithstanding the threatening aspect of these nocturnal beetles they are entirely harmless.

Among the FLOWER-BEETLES, so called because many of them feed upon the pollen of flowers which they visit for this purpose, are many enemies to our trees. Yet they are not always injurious in eating the pollen, as a number of them repay any small damage they may cause by pollenizing the flowers visited. Of course if they also eat ripe fruits, corn in milk, or other useful substances, they become troublesome. Most of these fairly large and frequently brightly colored beetles are flattened or nearly level on the back; the claws of the tarsi are of equal size.

THE SOUTHERN JUNE-BEETLE, OR FIG-EATER.

(*Allorhina nitida* Linn.).

This beetle, luckily not found in Minnesota, but occurring not far from our southern borders, is a good-sized insect, an inch

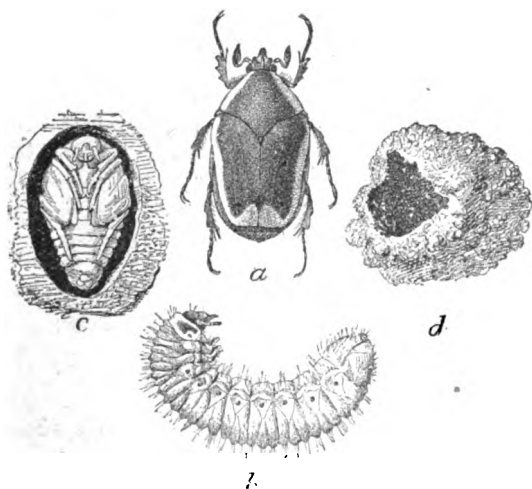


Fig. 106.—*Allorhina nitida*, Linn.—After Division of Entomology, U. S. Department of Agriculture.

or more in length, which during the day flies about with a buzzing sound like that of a bumble-bee, and like it usually close to the ground, excepting when invited by ripe fruit in the trees. It is somewhat pointed in front, of a velvety-green color, with the sides of thorax and head brownish-yellow. The under side is not velvety, but is polished metallic-green, like the entire head,

or is dark brown with a metallic-green tinge. The thighs of the legs are yellowish-brown. The beetle varies greatly in size and coloration; some measure not much more than half an inch. and some are also almost entirely dull brown with simply one or two broad longitudinal stripes of green upon their elytra. The insect is illustrated in (Fig. 106), which also shows the peculiar shape and sculpture of the head.

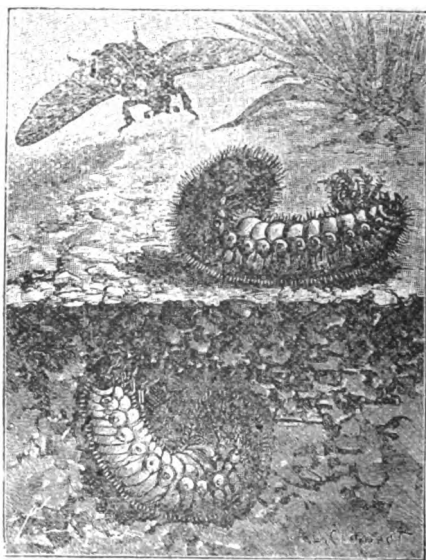


Fig. 107.—*Cetonia*, and larva traveling on back.

These beetles are very common in the South, and cause considerable damage. Their larvæ are found in richly manured soil, where they feed upon decaying vegetable matter, and not upon the roots of living plants. They are large white grubs, tougher than most of those of the common May-beetles, very hairy, with short legs, which forces them to travel on their backs instead of their legs when removed from their burrows. To enable them to travel in such a ridiculous manner they possess stiff bristles upon their backs, which propel them with ease and rapidity even over smooth ground. If put upon a table in the normal position,

they immediately turn upon their backs, and by the alternate contractions and expansions of their body segments they wriggle away in a straight line. This is also shown in Fig. 107.

Remedies against the adults are of little avail. Prof. Smith says that a heavy top dressing of kainit and tobacco has proved to be as effective as anything in dealing with the larvæ in the ground. If the trouble is only local, for instance if only small lawns are injured by their presence, kerosene emulsion, diluted ten times with water, and then washed into the soil by frequent waterings or by rain, has proved effective. This remedy has been very successfully applied in Washington. But as the larvæ feed upon decaying vegetable matter, or only in soils richly manured, their presence in large numbers is only injurious in dry weather, since the burrows made by them have the influence of drying the soil very rapidly. During a wet season the damage they cause is very slight, and many such grubs may be in a lawn without in any way revealing their presence. The insect is injurious only in the winged stage, and very decidedly so if at all numerous.

The genus *Euphoria* represents the more typical flower-beetles, which are distinguished by the margin of each wing-cover having near its base a large wavy indentation, which enables these sun-loving insects to expand their true wings very rapidly, hence they can fly as soon as they wish, without any long preparation, which is necessary in other cases described before. The mouth of such beetles is provided with a brush for sucking pollen. A number of such beetles are found in Minnesota, but only one is very common and decidedly injurious.

THE INDIAN CETONIA.

(*Euphoria inda* Linn.).

This is a yellowish-brown beetle, having the wing-covers covered all over with small and irregular black spots, which in some well-marked specimens form confused bands across the wing-cases. The whole insect is covered more or less densely

with short, fox-colored hairs. The under side of the black, and also hairy; the legs are dull black. The species greatly in color and markings; when quite fresh, especially in summer, they are very much brighter than early in the year after hibernating all winter in the ground.

These beetles are the earliest and latest of our flower-visitors. In spring, long before vegetation has started, they may be seen flying along close to the ground, with a loud, humming sound. Moist spots, especially near fresh manure, are frequently visited by them. During the early summer none are seen, but they again become numerous, and now they frequent the flowers of thistles in great numbers. This would not constitute their principal food, but these beetles are also very fond of both tassels and grains of corn plants, and equally so of the young corn stalks, and of milk, from which they suck the juice. Still later they invade the ripening fruits of all kinds, and burrow in them almost to the middle, as can be seen in the illustration, (Fig. 108, Plate II). In this manner they destroy ripe apples, pears, peaches and plums, and if they do not actually eat these substances entirely, they at least cause decay. Fruit left to dry is frequently injured by them. The normal food consists of the sap of trees, which exudes from bruised and wounded trees, and it is not uncommon to see them swarm about a bleeding tree as they do about a swarm of bees. They are very active and fly almost as fast as the tiger-beetles; they are also very strong, and it is impossible to hold them between the fingers, excepting by the use of such force as to crush them.

Many years ago, when engaged by Dr. Le Baron to make illustrations of beetles for him under the direction of Prof. H. C. Whittier, the writer had collected many balls of the common turnip, so as to obtain its eggs and larvæ. Incidentally a white larva was added to these balls, which were kept in a tin box, and it was found that this larva ate into such balls. The larva was found to be the beetle under discussion.

When the beetles fly about in search of places in which to deposit their eggs, they may be seen in large numbers

over refuse heaps coming from the kitchen. Here at the Experiment Station spoiled melons, potatoes and similar substances are carted away to a low place in the adjoining fields, where they decompose. This is the headquarter for such beetles and the ground is crowded with their larvæ. As there is no vegetation growing in these places the larvæ evidently feed only upon such decaying material. These, as well as those mentioned before as feeding in old manure, are almost entirely used for bait by the young fishermen living in the vicinity of our numerous northern lakes; they use them simply because in such places the angle-worms have not yet been introduced.

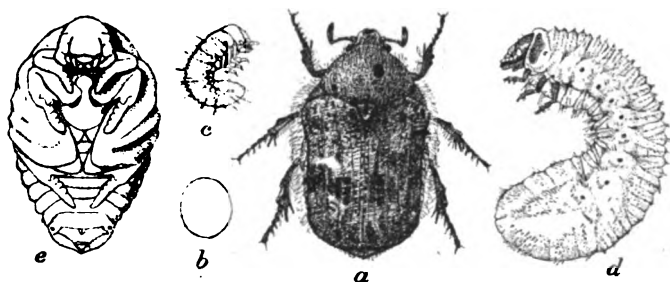


Fig. 109.—*Euphoria inda*, Linn.—After Division of Entomology, U. S. Department of Agriculture.

The larva of the *E. inda* is more robust than the common white grub, especially the abdominal segments. Mandibles and legs are short, the spiracles are prominent, and there is a yellow plate on the side of the first thoracic segment. These larvæ also travel upon their backs with great ease, but not so swiftly as those of the Fig-eaters. The different stages of this noxious beetle are given in the illustration (Fig. 109).

THE MELANCHOLY CETONIA.

(*Euphoria melancholica* Gory).

This beetle is a little smaller than the one just described, and is dark brown, almost black, with wavy impressed lines across the wing-covers, which are made prominent by being filled with

white scales. The insect looks polished and a little metallic, and has only the thorax covered with fine hairs, barely visible except in certain lights. It is not nearly so numerous, but otherwise has similar habits as *E. inda*. It is most frequently found in flowers. In the South, where it is much more common, it is often found about the holes made by the boll-worms in cotton-bolls, evidently enjoying the exuding sap. The beetle looks similar to the one illustrated in Fig. 107, but is also illustrated in Fig. 110.



Fig. 110.—*Euphorium melancholica*, Gory.—After Saunders.



Fig. 111.—*Osmoderma eremicola*, Knoch.—After Harris.



Fig. 112.—*Osmoderma scabra*, Beauv.—After Harris.

A number of other species of this interesting genus of beetles occur only in the nests of ants. It is difficult to account for their presence, but it is believed that their larvæ are beneficial to the colony of ants by cutting up the wood and roots found in the lower parts of the nest. They may, perhaps, also secrete some sweet liquid, used by the ants as food. At least some closely allied beetles, belonging also to the flower-beetles, to the genus *Cremastochilus*, are known to furnish food to the ants, hence are protected by them.

THE HERMIT FLOWER-BEETLES.

(*Osmoderma eremicola* Knoch).

This and the closely allied ROUGH FLOWER-BEETLE (*O. scabra* Beauv.), are rather large insects measuring an inch or more in length, the former species being the largest. Both species are

fairly common in Minnesota, and are frequently received by the entomologist to name them and describe their habits. The former, (*cremicola*), is a flat, deep mahogany-brown beetle, nearly smooth and highly polished. The latter, (*scabra*), is purplish-black, and has the wing-covers roughened with irregular and coarsely punctured striae; it has a bronzed appearance. Both beetles are nocturnal in their habits and hide during the day near the base of trees. Though not frequently seen they are common enough. The insects feed upon the sap of injured trees, but have also been seen enjoying a ripe apple. Fig. 110 shows *O. cremicola* and Fig. 112, *O. scabra*.

The larvæ of both species live in the decaying wood of the apple, as well as that of the cherry and other trees; here they consume the wood and induce more rapid decay. The larva is a large, fleshy "white grub", with a hard and reddish head and horny scales on the prothorax. When mature, late in autumn, each larva forms for itself an oval cell of the fragments of wood, which are cemented together with a glutinous material so as to be water proof. Inside this cocoon it undergoes its transformations, appearing as a beetle during the month of July, August, or early September. Frequently a number of such larvæ are found together in the same place, and in this case they can cause considerable injury.

Some closely allied beetles are also lovers of fruit and flowers, but cause no damage. The peculiarly marked *Gnorimus maculatus* Knoch was once found in large numbers eating the flowers of the shadberry, a plant frequently grown not only for ornamental purposes but also on account of its pleasantly flavored fruit. Several species of a still smaller species of flower-beetles belonging to the genus of *Trichius* are very fond of flowers, and especially so of the rose; here they sometimes cause much injury by eating both pollen and petals. They are diurnal in their habits, and are readily detected in such flowers. Some of these beetles are very pretty, of a brown, black, dark blue, or even metallic green color, marked with white lines, and an abundance of soft hairs, as may be seen in Fig. 113, Plate VI.

The vegetable-feeding lamellicorn beetles contain many beneficial insects, but a number of more or less injurious causing, generally speaking, but slight losses. But most larvæ are decidedly injurious, and all are similar in shape, well known "white grubs". Prof. Smith writes that:

"Taken as a whole, the lamellicorns contain no direct beneficial insects, and the white-grub larvæ are in many cases injurious when they feed on the roots of cultivated plants. As a variety of cultivated crops follow each other, there is a chance for their excessive development, and frequent injury is therefore indicated, with as short a period in grass as in other crops. As the beetles in most cases appear in spring, and oviposit in May or in June, land bare at that time will probably escape injury. In sowing of crimson clover, to be turned under by the end of May or before, will in some cases protect the land and crops from green manure if required; or it may be allowed to remain until mature to make hay, and, if then ploughed and put into a crop or some crop which the white grubs do not attack, such as clover in the ground will be starved out. Where white grubs are abundant, strawberries should not follow soil or other grass crops directly, and the beds should be kept clean, at least through the second year. Where the culprits are species of *Laccophilus*, fall ploughing is indicated, since this will turn out the formed beetles at an unseasonable period, and will cause the death in most cases".

E. PLANT-EATERS.

(*Phytophaga*).

We now reach the large series of beetles which belong to the *Phytophaga* or *Plant-eaters*, beetles distinguished by their long and thread-like feelers, and which possess apparently four-jointed tarsi, with the third joint deeply lobed. This series of beetles, less injurious beetles is divided into two families, the *Cerambycidae* or Long-horned Beetles, (Bock-käfer of the Germans), and the *Chrysomelidae*, or Leaf-beetles.

There is still another small family of beetles that is located between the lamellicorns and the true cerambycids. It is the family *Spondylidae*, composed of but a few species of beetles. One of them is very common in Minnesota, especially under the bark of pine trees. It is the BROWN PARANDRA, (*Parandra brunnea* Fab.), an insect of a mahogany-brown color, highly polished, with short feelers, which have deep impressions in which are situated the organs of special sense. It is shown in (Fig. 114, Plate IV).

FAMILY LONG-HORNS.

(*Cerambycidae*).

This large family contains about six hundred described species in North America alone. The beetles composing it are of medium or large size, graceful in form, and some are very beautiful in color and markings. Their body is oblong, often cylindrical, with a vertical, broad head armed with large mandibles. The eyes are peculiar, being hollowed out (*lunate*) on the inner side, with the feelers implanted in the hollows; the latter are long, sometimes longer than the whole body, tapering towards the tip, especially in the males, and are, with the exception of the *Prionidae*, composed of eleven joints. Their legs are also usually very long, and the joints of the tarsi, with long claws, are well adapted to anchor them safely upon the trees on which they hide and feed. Nearly all long-horns can run and fly with almost equal ease, but some species living in the Western treeless prairies possess no true wings. As a general rule, however, these beetles depend more upon hiding for their safety than upon running or flying, and in many cases their colors and markings blend exceedingly well with the objects upon which they rest. When held between the fingers some of them can produce a sort of indignant squeaking by rubbing together the prothorax and mesothorax; but some of them also produce this sound, *stridulation*, to call their mates.

The larvæ are borers, living in the solid parts of trees and

shrubs, or beneath the bark. They are white or yellowish, with a soft body, in which the joints are well separated by deep incisions, and which tapers slightly from head to tail. The first joints are usually enlarged and hammer-shaped, and covered with a horny plate, but are not flattened as are those of the "saw-horned borers" already described. Some larvæ possess the usual number of very small thoracic legs, but the majority have no legs at all, and move up and down in their burrows by alternate contractions and extensions of the body, or by means of peculiar projections or hunches on the segments. Many of them keep one end of their burrow open, through which they push out the frass, (chips and castings), and their presence is often detected by the little heaps of sawdust on the bark or beneath it on the ground; others are, however, entirely enclosed in their burrows, leaving the frass in a compact mass behind them as they extend their burrows in front.

In contradiction to the "saw-horned" or "flat-headed borers" they are frequently called "hammer-headed borers," or "round headed borers". All these larvæ possess powerful jaws which enable them to chew food composed of the hardest wood. After passing one, two, or three years in the larval state they transform to pupæ inside the burrows, and soon afterwards change to the adult beetles. Before changing to a pupa the larva in many cases transforms a portion of the long burrow into a pupal chamber by means of a plug of chips. With few exceptions such larvæ attack only dead or dying trees, or plants weakened in some way, perhaps by fire, by transplanting, by pruning, by storms, or by insects belonging to other families of beetles.

This extensive family is divided into three sub-families, which are separated as follows:

- A. Sides of the prothorax with a sharp margin. . . . *Prioninae*.
- A. A. *Prothorax not margined*.
- B. Front tibiæ not grooved; palpi never acute at tip. . *Cerambycinae*.
- B. B. Front tibiæ obliquely grooved on the inner side:
palpi with the last segment cylindrical and pointed. *Laminae*

The PRIONIDS (*Prioninae*) are large, sometimes very large beetles. They have the sides of the prothorax prolonged outwards into a thin, more or less toothed margin. The wing-covers are usually leathery in appearance, and of a brownish or blackish color.

THE BROAD-NECKED PRIONUS.

(*Prionus laticollis* Drury).

This gigantic borer, not uncommon in our state, measures in the larval stage from two and a half to three inches in length; it is of a yellowish-white color, with a small, horny, reddish-brown head, to which are fastened exceedingly dark and hard jaws; a bluish line marks the center of the back. This large grub cuts a cylindrical hole a little below the surface of the ground, into the roots of plants, such as the grape-vine, blackberry, oak, cherry, and apple. If the root is small, barely large enough to contain the larvæ, nothing but a thin skin of bark is left to hide the intruder. The same larva is sometimes also found in open prairies away from other roots than those of the plants growing in such places. In such cases the borer is an external feeder, but it never grows to the formidable size of others feeding inside of roots, and as a consequence the adult beetle of this form found in prairies are much smaller, and of a very much lighter color. The larva feeds for about three years, when it changes toward the end of June to a pupa within the root it had occupied. Of course where such borers abound the injury is great, and if a tree is badly infested nothing remains but to dig it out and burn it. Even large trees can be killed by such borers; the grape and apple seem to be able to stand the injury better than other plants, but they also suffer very much, even if not killed outright. In berry patches infested with such insects a sudden wilting of the plants in a hill, or part of a hill, indicates their presence, and steps should at once be taken to find and destroy them.

The beetles, which vary in length from less than one inch to two inches, and even more, are of a pitchy-black color; in the

prairie forms they are sometimes yellowish-brown. They possess powerful jaws; the twelve-jointed feelers are in the female rather slender, in the male longer, stouter and toothed; the thorax is short and wide, armed at the sides with three teeth. The leathery wing-covers have three slightly elevated lines each, and are thickly punctate. The female is a rather bulky beetle, the male much smaller with a shorter body. The illustration, (Fig. 115), shows this beetle in its various stages, and Fig. 116, Plate VI one still in its burrow but ready to leave.

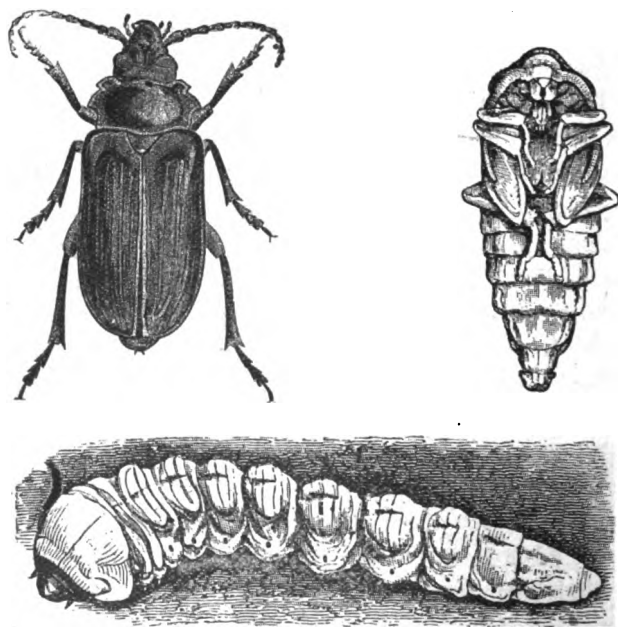


Fig. 115.—*Prionus laticollis*, Drury.—After Riley.

Another species (*P. imbricornis* Linn.), or the "Tile-horned Prionus," is also found in Minnesota; it is similar to the one described, and has the same habits, but is not so common. The early stages are almost identical in appearance, but the male beetle has received the above name because the joints of the feelers overlap one another like tiles on a roof. There is another



Fig. 117.—*Prionus imbricornis*, Linn.
Male.—After Riley.



Fig. 117½.—*Phymatodes amoenus*,
Say.—After Division of Entomology,
U. S. Department of Agriculture.

rather remarkable difference in these two species, viz.: *laticollis* has in both sexes twelve-jointed antennæ, while in *imbricornis* the feeler of the male is composed of nineteen, that of the female of about sixteen joints. Fig. 117 shows the male of *imbricornis*.

The TYPICAL CERAMBYCIDS, (*Cerambycinae*), contain about four hundred North American species, divided into more than one hundred genera.

THE GRAPE-VINE PHYMATODES.

(*Phymatodes amoenus* Say).

This beautiful beetle is frequently sent to the entomologist as being destructive to the grape-vine. But this is not exactly the case, although there is no doubt that it is frequently found about such plants. But it only feeds in its larval stage in dead or dying wood, hence all vines properly trimmed will not harbor it. The dead vines of the wild grape, however, offer an excellent abode for it. The beetles are bright blue, with a yellowish-red thorax. They appear in spring, and deposit their eggs in dead or dying canes. The beetle is shown in Fig. 117½.

Closely allied species of *Phymatodes* are frequently very numerous about cordwood; here they breed in such numbers that the bark is often loosened by their larvæ, and slips off entirely

during the following spring. The wood-men on that account call them "Bark-slippers." Other species in the Southern States are very apt to injure tan-bark. Trees cut in summer or autumn, after the beetles have disappeared, are not attacked by them in the following season, and escape injury.



Fig. 118.—*Hylotrupes bajulus*, Linn.—After Brehm.

Hylotrupes bajulus Linn., a beetle very similar in form to some species of *Phymatodes*, is shown in Fig. 118; it is one of those longicorn beetles that burrow in the larval state in dead wood, even after it has been used for building purposes.

THE BELTED HICKORY-BORER.

(*Chion cinctus* Drury).

This common beetle, (Fig. 119), distinguished by its narrow wing-covers, which are armed with two little teeth toward the tips, is of a hazel color, with a tint of gray produced by the short hairs covering it; it is also marked by an oblique yellow band across each wing-cover, not always present. The thorax is armed with a short spine on each side. The

of the male are more than twice the length of the body, which measures from three-quarters of an inch to one and a quarter inch in length.

The larva of this beetle feeds in the wood of hickory and walnut. Here it forms long galleries in the trunk in the direction of the fibers of the wood, and in such a gallery it later undergoes the transformations to a pupa and adult.

Besides the trees mentioned above as furnishing food to these larvæ, others are equally infested, as the oaks; even plum and apple trees do not escape.

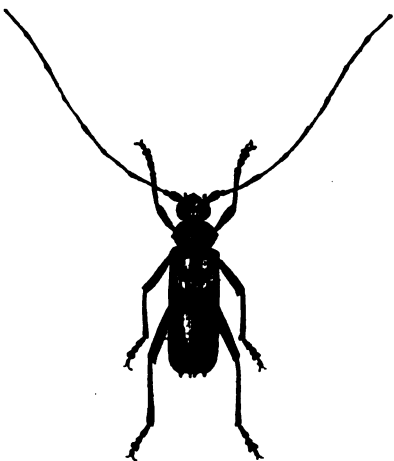


Fig. 119. — *Chlon cinctus*, Drury. — After Harrie.

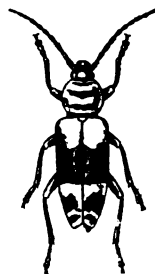


Fig. 121½. — *Cyllene decorus*, Oliv. — After Leconte.

OAK PRUNER.

(*Elaphidion parallelum* Newm.).

The name "oak-pruner" does not mean that the larvæ of these destructive beetles devote all their attention to oaks; they are also found in the apple, hickory, cherry, and other trees. The name "pruner" is very descriptive as the larvæ, when nearly full grown, girdle the twigs and branches inhabited by them from the inside, not the outside, so that the first high wind of autumn and

early winter breaks them off, dropping twig and larva on the ground. To girdle a twig from the inside is a nice trick, but it is difficult to explain how the larva succeeds in performing it. When we look at one of the squarely cut off twigs we can detect that it has been cut in a spiral manner. The purpose of cutting them off seems to be plain, being done to prevent the decay of the wood, which in contact with the ground and covered with snow during the winter, is not apt to become too dry for the requirements of the enclosed insect. In such burrows made in the tips of twigs and smaller branches, the larva lives and completes its transformation in the month of June following.

Under infested trees we can find such fallen twigs in great numbers during the fall, and as they contain the culprits it is a course very simple to gather and burn them. These insects are, however, not an unalloyed evil, as they tend to make the trees near the house much denser by forcing the plant to produce a number of small twigs instead of a few large ones.

The insect also attacks the wood of young shoots, and if these should have been injured by fire, or by the trampling of cattle. The writer has seen an extreme case, in which the trees in less than five years destroyed all the young growth of trees over an area of several hundred acres. In this case the land was covered with a very dense growth of black locusts, hickories, hazel and other plants. As soon as cattle were permitted to force their way through this tangle of small trees to reach the pastures surrounded with pastures, narrow cattle paths were first made, which soon widened to broad avenues, as the bruised trees invited destruction by all kinds of insects, but especially by the pruners. Their presence could easily be detected by the fact that the whole ground was covered quite deep with pruned twigs. Five years later only a few stumps of the larger trees, with the exception of some few poplars and willows that sprang up again, as the oaks disappeared, remained.

The adult beetles are very elongated, brown, covered with whitish, mottled pubescence; they have long and rather

tennæ, which in some species are armed with horns; their narrow wing-covers possess two smaller pointed projections at their posterior extremity, one on each side.

A number of species occur, all similar in general appearance and habits. The PARALLEL ELAPHIDION (*E. parallelum* Newm.), is the most common one. The female lays eggs near the axil of one of the leaf buds, where the young larva also enters the twig, enlarging the channel as it increases in size.

The APPLE-TREE PRUNER, (*E. villosum* Fab.), is very similar in general appearances. The feelers of the male are longer than the body, which is covered with short grayish hairs, which in some places are crowded together on the thorax and elytra, forming pale spots. The under side of the body is chestnut-brown. Prof. Saunders describes the habits of this species of beetle as follows:

"The peculiar habits and instincts of this insect are very interesting. The parent beetle places an egg in the axil of a leaf on a fresh green twig proceeding from a moderate sized limb. When the young larva hatches, it burrows into the center of the twig, and down towards its base, consuming in its course the soft pulpy matter of which this part of the twig is composed. By the time it reaches the main limb, it has become sufficiently matured to be able to feed upon the harder wood, and makes its way into the branch, when the hollow twig is vacated, gradually withers, and drops off. The larva, being now about half grown, eats its way a short distance through the middle of the branch, and then proceeds deliberately to sever its connections with the tree by gnawing away the woody fiber to such an extent that the first storm of wind snaps the branch off. This is rather a delicate operation for the insect to perform, and requires wonderful instinctive skill, for should it gnaw away too much of the woody interior the branch might break during the process, an accident which would probably crush the workman to death; but the insect rarely miscalculates; it leaves the bark and just enough of the woody fiber untouched to sustain the branch until it has time to make good its retreat into the burrow, the

opening of which it carefully stops up with gnawed wood. If the limb be short, it severs all the wood leaving it fastened only by the bark; if longer and the woody fibers on the upper side are left; and if very heavy, not more than three-fourths of the wood is gnawed through. Having performed the operation, and closed the opening, that the jarring of the branch when it falls may not dislodge the occupant, the larva retreats to the spot at which it entered the limb. After the branch has fallen it eats its

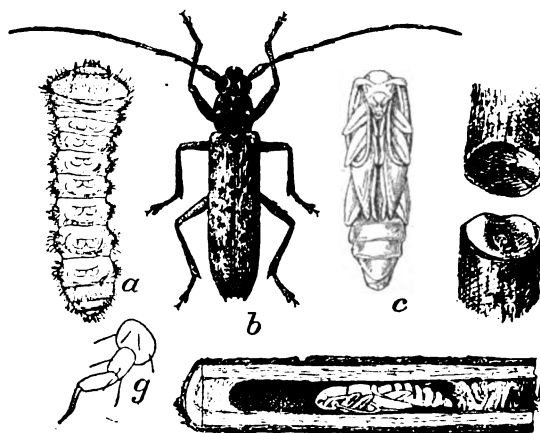


Fig. 120.—*Elaphidium villosus*, Fab.—After Division of Entomology, Department of Agriculture.

usually through the center of the limb for a distance of six to twelve inches, when, having completed its growth, it is transformed to a pupa within the enclosure. Sometimes the transformation takes place in the autumn, but more frequently it is delayed until the spring, and from the pupa the beetle escapes in the month of June.

"The larva, (Fig. 120), when full grown is a little more than half an inch long, thickest towards the head, tapering usually backwards. The head is small and black, body white, with a few indistinct darker markings. It has

minute legs attached to the anterior segments. The pupa is about the same size as the larva, of a whitish color, and is also shown in its burrow.

"Birds are active agents in the destruction of these larvæ; they seek them in their places of retreat and devour them. Should they at any time become very numerous they may easily be disposed of by gathering the fallen branches and burning them before the insect has time to mature."

Several other beetles of this genus are also destructive, and especially so in the orange-growing states, where the UNARMED GIRDLER (*E. inermis* Newm.), destroys the twigs of orange trees. It is called "unarmed" because the beetle lacks the two spines at the tip of the elytra. Of course it is not necessary for our fruit growers to prepare themselves to fight this beetle.

THE TWO-SPOTTED HICKORY BORER.

(*Tylonotus bimaculatus* Hald.),

This beetle, (Fig. 121, Plate V), equal in size to the "apple-tree pruner," but broader, is a rather pretty insect, dark-brown, with either two yellowish spots near the tips of the elytra, which are unarmed, or with four spots, two of which form almost a band across the wings. Our specimens in Minnesota are almost invariably four-spotted.

The larva of this beetle feeds in the wood of hickory, butternut, and walnut, and is sometimes quite numerous and correspondingly injurious by destroying the terminal twigs of such useful trees. It occurs also under the bark of the white or paper birch, and in the ash.

THE TWO-SPOTTED MOLORCHUS.

(*Molorchus bimaculatus* Say).

This peculiar small beetle, about a third of an inch in length, is not mentioned because it is very destructive, but because it differs from nearly all our longicorns in having the wing-covers only half as long as the abdomen. It has a very

slender body, black, with head and thorax coarsely punctured; each of the short wing-covers has a yellowish dash almost parallel with the inner margin; the feelers and legs are brownish.

The larva of this beetle has been found in hickory twigs and branches; also in those of the maple. The beetles themselves are very active, and fly about flowering shrubs during the warm and sunny days of June and July.

We have a large number of very prettily marked longicorn beetles which fly about during the day as actively as wasps, visiting flowers for the sake of their pollen and honey, and which race up and down the trees in which they were born or in which they intend to lay their eggs. Those interested in flowers, and especially in golden-rods, must have seen such beetles, usually of a dark brown or almost black color, marked with wavy golden-yellow lines across their wing-covers. A species not uncommonly found upon golden-rods in our prairies, away from any forests, is shown in Fig. 121½. It is *Cyllene decorus* Oliv. Some similar beetles are very destructive in their earlier stages, and on this account it is, or was, even forbidden to plant such trees as the locust. Maples, ash, hickories, walnut, butternut, and other trees suffer equally, and therefor two of the insects will be described and illustrated.

THE PAINTED HICKORY-BORER.

(*Cyllene pictus* Drury).

This and the LOCUST-BORER (*C. robiniae* Forst.), are very similar in size, color and markings. The illustrations (Figs. 122 and 123) on Plate IV are excellent ones and were kindly loaned by Prof. Webster, the entomologist of Ohio.

The former, (*pictus*), appears as a beetle only in spring; the latter, (*robiniae*), only towards fall, when large numbers of them may be collected upon the flowers of the beautiful golden-rod. The "painted hickory-borer" is a velvety black beetle, with numerous narrow, pale-yellow transverse bands upon the elytra and across the thorax. With a little imagination one of these

wavy lines looks like a "W". The legs are dark-red as are the feelers; in the "locust-borer" the yellow color is darker, and the wavy lines are usually a little broader.

The larvæ of both bore under the bark of their respective food-plants, and later into the solid wood, where they attain their growth in less than a year. The locust-borer is a serious pest, making the growing of the sweet-scented locust almost impossible in many localities, and in not a few places such trees have been completely destroyed. As soon as a tree attains a moderate size it is riddled with the large holes made by the larvæ, and for a few years leads but a sickly life, eventually dying down to the ground.

Prof. Packard in his fine work: "Insects Injurious to Forest and Shade Trees" gives the following remedies against such borers as the *robiniae*; "An excellent way to save a valuable shade tree from the attacks of this borer is to thoroughly soap the trunk late in August, so as to prevent the beetle from laying the eggs early in September. All insects breathe through little holes; now, if a film of soap, or grease, or oil of any kind closes the openings of these breathing pores, the air cannot enter the respiratory tubes which ramify throughout the interior of the body, and the insect dies by asphyxiation, i. e. drowns." Harrison states that whitewashing and covering the trunks of trees with grafting composition may prevent the female from depositing her eggs on isolated trees. A coating of oil, whether it really kills the worms in the manner suggested or not, is an excellent remedy, as it is offensive to the female beetles. It is an improvement, however, to add a little Paris-green or London-purple which fill the cracks with a fine film of these poisons: if eggs are deposited the larvæ hatching from them will be poisoned in eating their way into the wood. To whitewash a tree looks bad, and moreover is apt to attract the beetles, as insects of this kind are attracted to white objects.

An allied, but larger species, varying from velvety brownish-black and unspotted to an intense black beetle with bright yellow spots, sometimes united into wavy bands, is getting rather com-

mon in our state, where it infests the ash. It is very destructive when at all numerous.

A large number of smaller but equally beautiful beetles belong to this family. All are more or less injurious, but not to fruit-producing plants, being most abundant in evergreen forests.

Some few other longicorn beetles also belong here, which are more or less injurious to wild plants. In places where the elderberries are utilized a most beautiful beetle is sometimes injurious, because its larva bores and feeds in the pith of these plants. The beetle is quite common in June and July, and is found resting upon the foliage, but is wide awake and ready to seek safety in flight.

The ELDERBERRY BEETLE, (*Desmocerus palliatus* Forst.), is dark blue with greenish reflections. The basal half of the wing-covers is orange-yellow, and in strong contrast with the rest of the body. The black feelers have the middle joints thickened at the outer ends, so that they look like a series of knots, for which reason the beetle is sometimes called "Knotty Horn". It is shown in Fig. 124, Plate VI.

There is another large series of very beautiful longicorn beetles which are frequently observed, as they are visitors to our flowers, in which, covered with pollen, they are sometimes barely visible. On account of this they are certainly beneficial, even if their larvæ burrow into the wood of trees. The wild chestnuts in more southern regions would not produce so many nuts if their flowers were not so profusely scented, thus attracting beetles of this kind, which are not slow to accept such invitations.

To show how at least one of these beetles looks, the description of *Gaurotes cyanipennis* Say, an insect living in the wood of butternut, is given. The beetle is black, tinged with copper; the feelers and legs are reddish-brown, and the elytra are of a most beautiful violet, blue or blueish green color, and are highly polished. It is shown in Fig. 125, Plate IV, and a member of the genus *Strangalia* in Fig. 126.

Among the LAMIID LONGICORNS (*Lamiinae*) we also have a large number of fine beetles, some of which are decidedly

injurious, not alone to forest trees, but to fruit-producing trees as well. Members of this group of beetles have a rounder prothorax, frequently armed with rather long thorns, but not always so; their fore-tibiæ are grooved on the inner side, and the last segment of the palpi is cylindrical and pointed.



Fig. 126.—*Strangalia spec.*—After Brehm.

THE AMERICAN CURRANT-BORER.

(*Psenocerus supernotatus* Say).

It is not uncommon at all to find a small larva in the branches and smaller shoots of our currant bushes, which in early spring changes to a small, brown, and slightly flattened beetle, rarely exceeding one-quarter of an inch in length. It is beautifully marked, although some specimens are almost unicolored. Bright-colored specimens are clothed with white hair, which is grouped so as to form two white spots towards the end of the wing-covers, frequently so broad as to join at the suture, in which case they are lunar in shape. In the center is another fine and wavy white line, sloping from the sides back to the suture, and enclosing an almost black space. The scutellum is also white.

If this insect (Fig. 127) should become abundant enough to become troublesome, it can be held in check by close pruning during the late fall or winter; the cuttings should be burned before spring to destroy the larvæ in them. According to Dr. Hamilton this beetle sometimes hibernates, as he found three of them in the folds of a *Cecropia* cocoon taken in February from the currant bush.

Although not an enemy to fruit-producing plants the SAWYER (*Monohammus confusor* Kirby) is so frequently seen, so destructive to pines, and so often received by the entomologist to be named, that its life-history will be given in a few words.

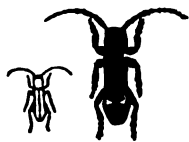


Fig. 127.—*Psenocerus supernotatus*. Say. After Saunders.

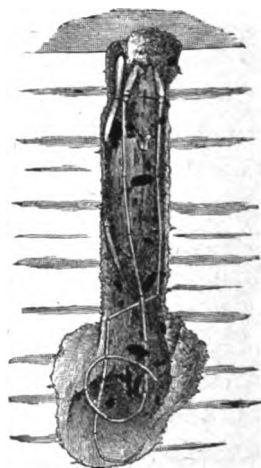


Fig. 128.—*Monohammus confusor*. Kirby.—After Division of Entomology, U. S. Department of Agriculture.

It is a beautiful brown or gray beetle, covered more or less densely with a silky down, most prominent upon the thorax, for which reason it is sometimes called the "Silver-bug." The elytra are mottled, with raised black dots or dashes; the thorax is armed upon each side with a large thorn. The beetle measures about one inch and a quarter in length, and is readily recognized by the long feelers, which in the female are as long as the body, and in the male twice as long. These enormously long antennæ

are in constant motion when the beetle is running about and point forward in this case; when the owner is asleep they bend backwards, and are close to the body.

The larva bores in the sound wood of pine and fir, making when full grown, a large hole, half an inch in diameter. It changes to a pupa, and soon afterwards to the adult beetle. Such borers are exceedingly numerous in our neglected pine forests, invading all the trees that are injured by fire, or which are bruised by trees felled by the axe of the wood-cutter. When everything is quiet the gnawing of such larvæ can be plainly heard in the dry trees, which act as a sort of a sounding board. This insect is shown still in its burrow in Fig. 128.

There is another insect, not as bulky, but nearly as long, with equally long horns, which in the Southern States is quite destructive to the mulberry. Our mulberry bushes are also invaded by a similar, but much smaller beetle, which is, however, not numerous enough to cause much injury.

The hickory is invaded by a number of borers, which in more southern regions cause the loss of many young trees. THE COMMON HICKORY-BORER (*Goes tigrinus* De Geer), and the BEAUTIFUL HICKORY-BORER (*G. pulchra* Hald.), as well as *G. oculatus* Lec. and *G. debilis* Lec. belong to this genus.

THE BEAUTIFUL HICKORY-BORER.

(*Goes pulchra* Hald.).

This insect (Fig. 129, Plate VI) is well named *pulchra*, meaning beautiful. It measures a little over an inch in length, is reddish-brown, and marked with dark brown in such a manner that across the wing-covers a band is formed, which gradually shades off into the general color of the beetle towards the tip. This marking of the wing-covers is produced by a close belt of fine hairs.

The beetle deposits eggs upon the different kinds of hickories, frequently selecting for this purpose the smaller trees, an inch or more in diameter. The presence of the larvæ inside

sometimes forces the trunk to enlarge at that point, so that a large gall-like swelling is produced. This of course kills the tree, which during a heavy wind breaks at this weak place.

There are a large number of small grayish longicorns, more or less sprinkled with white scales arranged in larger spots or irregular wavy lines, which infest all sorts of trees, and among them our fruit trees. The beetles look like the dead bark upon which they are usually found hiding. Most of them have their short thorax armed with a minute spine on each side, but this is not always the case. A few of the more important ones will be described. In case they should at any time become numerous enough to become destructive the dead twigs should be cut off and burned, and an alkali wash applied to the bark, as recommended against the "Round-headed Apple-tree Borer," a beetle to be described later.

THE LONG-HORNED BORER.

(*Leptostylus aculifer* Say).

This beetle (Fig. 130) is rather robust in shape, with long tapering feelers, ringed with black and white. It is of a brownish-gray color, with numerous small thorn-like points upon the wing-covers, and a V-shaped band, margined with black, a little behind the middle of the elytra. Some well marked and fresh specimens are little beauties, being almost silvery white, with dark dots on the band already mentioned. The insect measures a little more than one third of an inch in length. It is most common during August, when it may be found hiding on the trunks of apple-trees. Here, and also in other trees, it lays eggs, which shortly afterwards hatch into small grubs, which enter the tree, burrowing under the bark.

Leptostylus macula Say, a very similar beetle, is also often found upon old apple-trees; it probably feeds in them as a larva.

The closely related genus *Liopus* also furnishes a contingent of beetles which feed in our orchards. These beetles are smaller and more elongated. In the next genus we find a small beetle which occurs in large numbers in old apple-trees.

THE APPLE LEPTURGES.

(Lepturges facetus Say).

This insect, though very small, as seen in the line under the illustration, (Fig. 131), is a very handsome, slender beetle, in some cases much less than a quarter of an inch long; it is of a pale ash-gray color, with a purplish tinge. The rather long and hairy feelers are yellowish-brown, and are ringed with black at the tips of each joint. The smooth wing-covers possess an irregular dark spot on their anterior portion, and a broad black band across the posterior part, just leaving the tips pale-

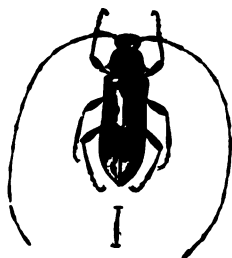


Fig. 130.—*Leptostylus aculifer*, Say. After Saunders.

Fig. 131.—*Lepturges facetus*, Say. After Saunders.

Fig. 132.—*Oncideres cingulatus*, Say. After Riley.

gray; other blackish spots and streaks are found elsewhere. These beetles occur most numerous during late June and in July, when they are engaged depositing their eggs on the bark of the branches, which the young larvæ enter, and in which they undergo their transformations before the next summer.

The larva has the usual form of such borers, is about a quarter of an inch long, slender, with the anterior segments enlarged and the abdomen rather blunt. It is entirely covered with fine and short hairs.

Many other beetles, which are all of about the same size, similar color and markings, are more or less injurious to fruit trees. By beating the small dead twigs of some trees, as the oak, chestnut, hickory and others, large numbers will fall into an

inverted umbrella held beneath, and this is one of the most common devices used by collectors of beetles to collect their pets.

THE TWIG-GIRDLER.

(*Oncideres cingulatus* Say).

This fine beetle, a little more than half an inch in length, has a very elegant but modest appearance, being of a gray color with dull reddish-yellow dots, and having a gray band across the middle of the wing-covers. The wing-covers are longer than the body.

It is of rare occurrence in Minnesota and not merely because it is injurious, but on account of its habit of gnawing the twigs of the hickory, pear and other trees, and its interest in laying eggs. The female lays an egg in a twig or branch, and it then girdles a little distance below, eating a groove about a tenth of an inch wide, and as deep, so that a high wind will blow the twig down. The foliage on such a twig wilts at once, and the tree is then in the exact condition desired by the larva, which goes through its transformations undisturbed by growth or by the moisture. Sometimes shade trees are also attacked, but the careful gathering and burning of the fallen wood keeps the damage in check.

The illustration (Fig. 132) shows the female beetle. Sometimes a number of twigs are thus amputated, and it is reported that a persimmon branch not more than two feet long contained as many as eight eggs, one egg being placed in each of the successive side shoots; in another case several eggs were crowded together in a small hickory branch about six inches long, which shows that this insect can become very injurious if at all numerous.

THE ROUND-HEADED APPLE-TREE BORER.

(*Saperda candida* Fab.).

This is one of the worst and most familiar orchard pests, preferring to bore into the apple, although the quince

infested; it also occurs in the pear, hawthorns and some other plants. The beetle appears late in June or July, and is not found in large numbers in our state. Prof Saunders gives the following condensed description of this beetle and its work:

"The Round-headed Apple-tree Borer is a native of America whose existence was unrecorded before 1824, when it was described by Thomas Say. The year following, its destructive character was observed about Albany, N. Y. It is now widely and generally distributed, and probably it was so at that time, although unnoticed, since it inhabits our native crab and thorn bushes, and also the common June-berry, *Amelanchier canadensis*. While preferring the apple, it also makes its home in the quince, pear and mountain-ash. In its perfect state it is a very handsome beetle, about three-fourths of an inch long, cylindrical in form, of a pale-brown color above with two broad creamy white stripes running the whole length of its body; the face and under surface are hoary-white, the antennæ and legs are gray. The females are larger than the males and have shorter antennæ. The beetle makes its appearance during the month of June and July, usually remaining in concealment during the day, and becoming active at dusk.

"The eggs are deposited late in June, in July and most of August, one in a place, in an incision made by the female in the bark of the tree near its base. Within two weeks the young larvæ are hatched, and at once commence with their sharp mandibles to gnaw their way to the interior.

"It is generally conceded that the larva is three years in reaching maturity. The young ones lie for the first year in the sap-wood and inner bark, excavating flat shallow cavities, about the size of a silver dollar, which are filled with their saw-dust like castings. The holes by which they enter being small, they are soon filled up, though not until a few grains of castings have fallen from them. Their presence may, however, be detected in young trees from the bark becoming dark-colored, and sometimes dry and dead enough to crack. Through these cracks some of the castings generally protrude and fall to the ground in

a little heap; this takes place especially in the spring of the year, when, with frequent rains, the heaps become swollen by the absorption of moisture. On the approach of winter the larva descends to the lower part of its burrow, where it doubtless remains inactive until the following spring.

"During the next season it attains about half its growth, still living in the sap-wood, where it does great damage, and when, as often happens, there are several of these borers in a single tree, they will sometimes cause its death by completely girdling it. After another winter's rest, the larva again becomes

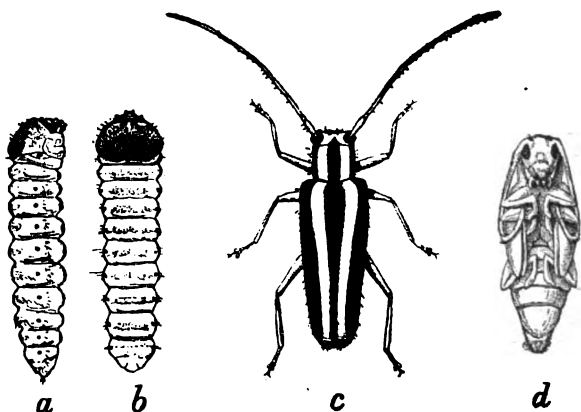


Fig. 133.—*Saperda candida*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

active, and towards the end of the following season, when approaching maturity, it cuts a cylindrical passage upwards, varying in length, into the solid wood, afterwards extending it outward to the bark, sometimes cutting entirely through the tree, at other times turning back at different angles. The upper part of the cavity is then filled with a sawdust-like powder, after which the larva returns to the part nearest the heart of the tree, which portion it enlarges by tearing off the fibers, with which it carefully and securely closes the lower portion of its gallery, so as to protect it thoroughly from the approach of enemies at either end. Having thus perfected its arrange-

ments, it again turns round so as to have its head upwards, when it rests from its labors in the interior of the passage until the following spring, when the mature larva sheds its skin and discloses the pupa. In this condition it remains for about two or three weeks, when the perfect beetle escapes. At first its body and wing-cases are soft and flabby, but in a few days they harden, when the beetle makes its way through the sawdust-like castings in the upper end of the passage, and with its powerful jaws cuts a smooth, round hole through the bark, from which it escapes.

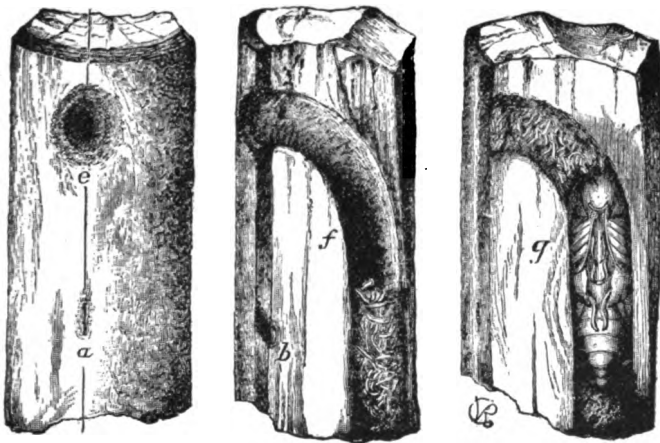


Fig. 134.—*Saperda candida*, Fah.—a, puncture in which egg is laid; b, same in section; c, hole from which beetle has emerged; e, same in section; f, pupa in its cell. After Riley.

"The larva, (Fig. 133), is of a whitish color, with a round head of chestnut-brown, polished and horny, and the jaws black. It also has a yellow horny looking spot on the first segment behind the head. It is without feet but moves about in its burrows by the alternate contraction and expansion of the segments of its body. When full grown it is over an inch in length. Fig. 134 shows the work of this borer.

"The color of the chrysalis is lighter than that of the larva, and it has transverse rows of minute spines on the back, and a few at the extremity of the body.

"Remedies: The young larva, as already stated, may often be detected by the discoloration of the bark. In such instances, if the outer dark-colored surface be scraped with a knife, late in August, or early in September, so as to expose the clear white bark underneath, the lurking enemy may be discovered and destroyed. Later they may be detected by their castings, which have been pushed out of the crevices of the bark, and have fallen in little heaps on the ground. When first discharged they look as if they had been forced through the barrels of a minute double-barreled gun, being arranged closely together in two parallel strings. Those which have burrowed deeper may sometimes be reached by a stout wire thrust into their holes, or by cutting through the bark at the upper end of the chamber, and pouring scalding water into the opening, so that it may soak through the castings and penetrate to the insect.



Fig. 135.—*Saperda cretata*, Newm.—After Division of Entomology, U. S. Department of Agriculture.

"Among the preventive measures, alkaline washes or solutions are probably the most efficient, since experiments have demonstrated that they are repulsive to the insect, and that the beetle will not lay her eggs on trees protected with such washes. Soft soap reduced to the consistency of a thick paint by the addition of a strong solution of washing-soda in water, is perhaps as good a formula as can be suggested; this, if applied to the bark of a tree, especially about the base or collar, and also extended upwards towards the crotches, where the main branches have their origin, will cover the whole surface liable to attack; and

if applied during the morning of a warm day, will dry in a few hours, and form a tenacious coating, not easily dissolved by rain. The soap solution should be applied early in June, and a second time during the early part of July."

There are other species of *Saperda*, all injurious to trees. *S. obliqua* Say feeds in the wood of alder and hazel; *S. calcarata* Say is decidedly injurious to the poplar and cottonwood; *S. cretata* Newm. (Fig. 135), a beautiful beetle, very similar to *candida*, but with the white bands twice interrupted, also has similar habits, being found upon apple and thorns (*Crataegus spec.*); *S. vestida*, Say, *S. tridentata* Oliv., and *S. lateralis* Fab., occur upon a variety of forest trees, such as linden, poplar and others. *S. discoida*, Fab., is destructive to hickory; *S. concolor*, Lee, forms gall-like swellings on the younger trunks of the aspen; *S. puncticollis* Say is found in the stems of the poison ivy and oak.

THE RASPBERRY CANE-BORER.

(*Oberea bimaculata* Oliv.).

This beetle is similar to the species of *Saperda*, but it has a much longer and more narrow black body; the surface of the thorax and the fore part of the breast is pale-yellow, with two small black spots, absent in some specimens; or there is an additional small black spot on the posterior edge of the prothorax, just where the elytra join the same. The elytra are covered with coarse indentations, and are slightly notched at the ends. Fig. 136, Plate IV shows this beetle and its work.

Such, or similar beetles belonging to this genus, as the *O. flavipes* Hald., which is black with yellow legs, appear during the month of June, and after pairing the female deposits her eggs in the canes of the raspberry and blackberry in a very singular manner: "With her mandibles she girdles the young growing cane near the tip in two places, one ring being about an inch below the other, and between the rings the cane is pierced, and an egg thrust into its substance near the middle, its location

being indicated by a small dark-colored spot. The supply of sap being impeded or stopped, the tip of the cane above the upper ring soon begins to droop and wither, and shortly dies, when a touch will sever it at the point at which it has been girdled.

"The egg is long and narrow, of a yellow color, and quite large for the size of the insect, and, embedded in the moist substance of the cane, absorbs moisture and increases in size until in a few days a small white grub hatches from it. The larva as it escapes from the egg is about one-fourteenth of an inch long, with a yellow, smooth, glossy body, roughened at the sides, and clothed with very minute short hairs. The head is small and reddish-brown, and the anterior segments of the body are swollen; the larva is also footless. The young larva burrows down the center of the stem, consuming the pith, until full grown, which is usually about the end of August, when it is nearly an inch long and of a dull-yellow color, with a small, dark-brown head. By this time it has eaten its way a considerable distance down the cane, (Fig. 136, Plate IV), in which it remains during the winter, and where it changes to a pupa, the beetle escaping the following June, when it gains its liberty by gnawing a passage through. This borer injures the blackberry as well as the raspberry.

"The presence of these enemies is readily detected by the sudden drooping and withering of the tips of the canes. They begin to operate late in June, and continue their work for several weeks; hence by looking over the raspberry plantation occasionally at this season of the year and removing all the tops *down to the lowest ring*, so as to insure the removal of the egg, these insects may be easily kept under, for they are seldom numerous."

Other species of this genus in their larval stage make long cylindrical burrows in the twigs of the cottonwood and other related trees.

Longicorn beetles are generally favorites with collectors of insects, and are better known as beetles than as larvæ. But even people not collectors are familiar with some species, since these do not hide, but fully expose themselves on the plants they infest. This is especially true of certain longicorns that are found upon

the stems and leaves of our milkweeds, since they are of a brilliant red color, marked with a number of black spots upon the elytra and thorax. As larvæ they feed in the roots of a number of species of *Asclepia*.

FAMILY CHRYSOMELIDAE.

(*Leaf-beetles or Chrysomelids*).

The name "leaf-beetle" is well chosen, as these beetles feed both as larvæ and as adults upon the leaves of plants. The scientific name was selected for them from two Greek words, meaning *golden apple*, since most of these insects display brilliant and beautiful colors, and also because their form is usually round and oval. Such beetles are mostly short-bodied, more or less oval in outline; the head is very short, much narrower than the prothorax; the feelers are usually of moderate length, somewhat enlarged towards the tips, and set wide apart; the eyes are round and prominent; the legs are usually short and stout, and are furnished with tarsi of the same type as those of the preceding family, being also broad and cushioned beneath.

All our species in Minnesota can readily be distinguished from the longicorns, but such is not the case in other regions, where forms occur that are not easily placed in the families to which they belong. Most of our species are small, the well known "Colorado potato-beetle" being about the largest representative we have.

The larvæ are variously formed, but are mostly thick, broad, with well developed true legs. They live exposed upon leaves; some mine between the upper and lower cuticle of the leaves; still others cover themselves with their own excrement, while a few bore into the stems and roots of plants.

The eggs are usually deposited in small masses upon the leaves or stems of the plants upon which the larva feeds, and are frequently elongated and of a yellowish or orange color.

Leaf-beetles are very numerous, about six hundred species being found in North America alone. They are arranged in a

number of groups. Since all are vegetable feeders, they are more or less injurious, and sometimes, if they attack cultivated plants, they are very much so. Happily but few of them do so; many others feed upon worthless, even injurious plants, as weeds.

It is not possible to give a description of many of these beetles in this report, not even of the eleven tribes into which the family is divided. But to give some idea of their classification a few of the more common ones will be described, even if they are not destructive.

When we pick the flowers of the beautiful water lilies, (*Nymphaea*), we are apt to find that their leaves are more or less perforated with small holes, and if we look a little more close-



Fig. 137.—*Donacia*—life history.—After Brehm.

ly we find the culprits near by. (Fig. 137.) They are very active and graceful beetles, usually of a metallic color; they are generally gregarious, flying about actively in the bright sunshine. They can run over the water, and being protected with a fine pubescence on the under surface of their bodies do not become wet.

Early in spring, about the time that the maples are in bloom, we find many beetles in such flowers that belong to this family; they are evidently of some good to the plants, for they carry the

pollen from flower to flower, from tree to tree. They also occur in the flowers of the apple and plum. Their name is *Orsodacna atra* Ahr.

Closely allied to them is a most beautiful beetle, but one that is decidedly injurious. It is as yet not found in Minnesota, but no doubt will reach us before long from the east.

THE ASPARAGUS BEETLE.

(*Crioceris asparagi* Linn.).

This is a small, red, yellow and black beetle, as seen in the illustration (Fig. 138). It gnaws holes in the heads of young



Fig. 138.—*Crioceris asparagi*, Linn.—After Division of Entomology, U. S. Department of Agriculture.

asparagus, and lays oval, blackish eggs upon them. The young larvæ, which are brown and slug-like grubs, also eat the young heads early in spring, but later a second brood of them feeds upon the full-grown plant. Wherever this insect occurs it causes great losses, and steps should at once be taken to destroy it.

A beetle of similar shape, the *Three-lined Lema*, (*Lema trilineata* Oliv.), but of a yellow color, with three black stripes on the wing-covers, is very common upon our "husk-toma'toes," or

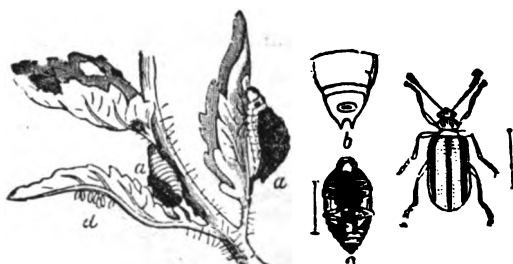


Fig. 139.—*Lema trilineata*, Oliv. After Riley.

"ground cherries," which are frequently entirely destroyed by them and their larvæ. These latter have the nasty habit of covering their backs with their own excrement. As they are also found injurious to the potato they should be killed with any of the arsenical poisons. We have two broods of this insect, the second brood hibernates in the ground as pupa. This species is illustrated in Fig. 139.

THE DOMINICAN CASE-BEARER.

(*Coscinoptera dominicana* Fab.).

This peculiar beetle is frequently found upon the leaves of the plum, apple, rose, oak, and other plants. It is not especially injurious, but as it is frequently seen and has a peculiar life-history, it will be described in a few words. The name "dominican" has been chosen because it is neither ornate in color, being uniformly bluish-gray, nor prone to make itself conspicuous. It is shown in all stages in Fig. 140. Its color is really black, with

the exception of a yellowish brown labrum, but this color is so densely covered with a bluish or ash-gray pubescence as to become invisible; the under side is even more closely covered than the upper one. The eggs are attached to all sorts of plants by long stalks, and are covered by deep brown scales of excrement, most beautifully arranged in such a manner that the egg seems to be enclosed in a pine cone. The mother, in covering the egg, holds it horizontally between the tarsi, adding the stercoraceous

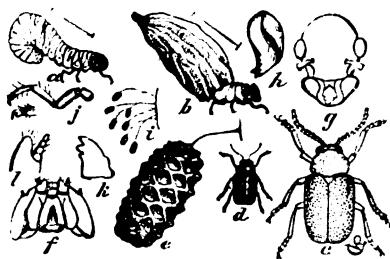


Fig. 140.—*Coscinoptera dominicana*, Fab.—After Riley.

covering in thin curved layers, which, in other related beetles, are pressed into various patterns by the anus. In many cases the female also possesses a little cavity at the tip of the venter, in which the egg is hidden if she is disturbed before the operation of covering it is completed. This egg hatches in about two weeks, and the young larva cuts itself loose from the shell or anchorage, and tumbling to the ground, has to shift for itself. The covering of the egg now forms a house for the young larva, which lives in it, gradually adding to the rim of the case, so that the house grows with its tenant. Inside it changes later to a pupa and perfect insect. The larva feeds upon dead leaves laying on the surface of the ground.

There is another beetle very common in our state, which so closely resembles the droppings of a caterpillar that but few expect it to be a living creature, especially as the beetle, if disturbed, drops to the ground and plays possum. The adult insect is a little oblong, cubical, roughly shagreened, metallic-green-

ish beetle, found very commonly upon the foliage of raspberries, blackberries, and that of other plants and trees. The larva of this beetle (*Chlamys plicata* Oliv.) is also a sac-bearer, as may be seen in the illustration (Fig. 141).

Other beetles, all not much longer than one-eighth of an inch, and belonging to the genera *Bassareus*, *Cryptocephalus*, and *Pachybrachys*, usually beautifully colored and marked with

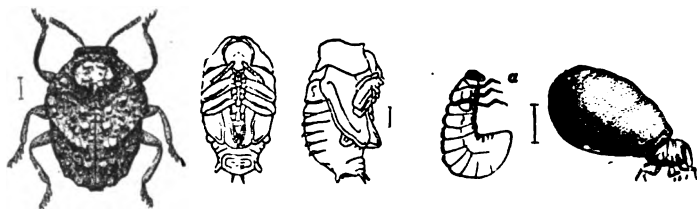


Fig. 141.—*Chlamys plicata*, Oliv.—After Marlatt (in part).

bright spots and lines, are also found upon the foliage of fruit-producing plants, but are not apt to cause any serious injury. The larvæ of most of them are not even known, but as far as discovered they are all sac-bearers, and live as such in or about the nests of ants.

THE GRAPE-VINE FIDIA.

(*Fidia longipes* Mels.).

Whenever this insect and some closely allied ones becomes at all numerous, it can cause considerable damage to the wild and cultivated grape. Some years ago nearly all the leaves of certain varieties of grape were destroyed by these beetles, which cut straight and elongated holes, into the leaves, about one-eighth of an inch in diameter, thus reducing them to mere shreds. The illustration, (Fig. 142), shows this insect. In the more southern states they sometimes literally swarm, and are in such cases perfectly able to destroy the entire foliage in even large vineyards.

Though very common, the beetle is not very often seen, as it is very watchful and shy, dropping to the ground upon the slightest disturbance; in falling it doubles up its legs, and thus rolls from the leaves, pretending to be dead. Knowing this habit large numbers can be captured by jarring them with a stick into an inverted umbrella. To make sure that they do not fly off again it is but necessary to line the inside of such an umbrella with some absorbent material, and soak this in kerosene oil. By doing so the oil will be kept in position, and any insect coming thoroughly in contact with it is doomed to die.



Fig. 142.—*Fidra longipes*, Mels.—After Saunders.



Fig. 145.—*Paria canella*, Fab.—After Forbes.



Fig. 144.—*Paria canella*—var. *6 notata* Say.—After Saunders.

The beetle is about a quarter of an inch long, is chestnut-brown, but so densely covered with short whitish hairs as to appear gray and hoary. It is found early in June, and only for a short time, after which it disappears.

THE GRAPE-ROOT WORM.

(*Fidia viticida* Walsh).

This beetle is very similar to the one described, and is a rather long-legged creature, covered with short hair, so that it appears gray. It is sometimes very injurious, especially in some of the Central States, as Ohio, but as it occurs over a large portion of our country it may cause injury almost anywhere and at

almost any time. This beetle also feeds, during June, upon the foliage of the grape, eating irregular holes into the upper surface. During this time the female also lays eggs on the trunk of the vine, or in any available crevice in the branches. In such places the eggs hatch, and the young larvæ drop to the ground, and entering it, make their way beneath it as well as they can. Eventually they reach the rootlets of the vines upon which they feed. The beetle is shown in its various stages in Fig. 143.

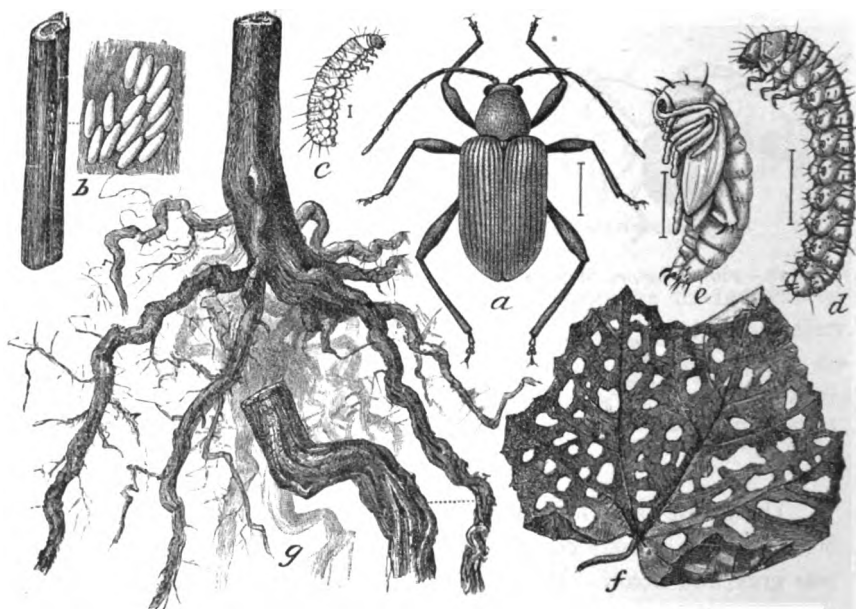


Fig. 143.—*Fidia viticida*, Walsh.—After Division of Entomology, U. S. Department of Agriculture.

So far remedial measures against the larva have not proven very satisfactory, but according to Prof. Smith, spraying with a strong arsenical mixture, using lime to avoid burning the foliage, will kill many of the beetles. Cultivating the ground so as to have a loose powdery top soil, without crevices leading to the roots, which should also be covered as deeply as possible, will prevent many of the larvæ from reaching their desired food.

There is still another beetle closely allied to the two species of *Fidia* just described. It is reddish-brown, a little smaller, more robust and is sometimes very common upon the foliage of the wild grapes. It is *Adoxus obscurus* Linn. Last year, late in July, it became very numerous upon some cultivated grapes, but could be readily gathered into an inverted umbrella. The beetles are very active and difficult to find when on the ground, the color of their bodies blending well with the surrounding particles of soil and refuse material.

One of the larger, and by far the most beautiful of all of our leaf-beetles is an insect very commonly found upon the two species of dog-bane growing in our state. Their form is characteristic of that of the following species, being elongated-oval. The beetle is entirely of a burnished metallic green color, with a darker bluish-green thorax. Various other tints, such as gold, brass, copper, appear if the insect is viewed in certain lights. Its name is a well selected one, being *Chrysochus auratus* Fab. It is frequently collected in large numbers by young people who arrange a number of butterflies in large glass cases in various patterns, as for instance in that of a flying eagle, and these brilliant beetles are frequently used to form the outlines of the picture.

THE STRAWBERRY ROOT-WORMS.

(*Paria canella* Fab. & others).

These very common beetles vary greatly in coloration and markings, and a number of varieties have been described. All are small, being about three-tenths of an inch long, polished, pale yellowish-brown, or darker, almost black, with two, four, or six black dots or spots upon the wing-covers. These spots are sometimes confluent, forming two longitudinal bands, or the black color may even cover the entire disk of the elytra; the under side is black. These stout beetles are very active in all their motions, moving about briskly when disturbed. They hibernate as beetles, and are very commonly found under rubbish along the edges of forests. From these places they frequently invade strawberry

beds, where they can become very destructive, and if at all numerous they devour the leaves of these plants with such avidity that they are soon riddled with holes, which of course materially injures the crop of berries. This is especially true of the Central States. In such cases the old beds should be plowed up and destroyed as soon as the crop has been picked, and new beds should be set out in fresh places, and for this purpose new plants are to be selected that were free from the attack of such root-worms. Wherever a two-year picking rotation is used, in which the old plants are immediately destroyed, this root-borer can not increase very greatly. Arsenical poisons are also very satisfactorily used to kill the adult when they are noticed upon the foliage, but it would be unsafe to do so when the fruit is already well set and large. Hellebore is also of use, and air-slaked lime dusted over the plants will, to some extent, lessen the trouble.



Fig. 146.—*Colas is flavida*, Say.—After Forbes (in part).



Fig. 148.—*Glvptoscelis crypticus*, Say.—After Saunders.

Prof. Forbes, who has studied, very closely the three species of strawberry root-borers, i. e., *Paria aterrima* Oliv., *Colaspis brunnea* Fab., and *Graphops pubescens* Mels., has also described the early stages of these beetles. He gives a full account of them in the "Thirteenth Report of the State Entomologist of Illinois." Like all his reports this one is of great value to the growers of all kinds of fruits.

By looking at the illustrations, (Fig. 145, 146, 147), which are reduced in size from the originals made by Prof. Forbes, we can perceive the structure of these beetles, and that of their earlier stages.

The larvæ are all small white grubs infesting the roots and crowns of the strawberry plants, eating the smaller roots, and penetrating and mining the interior of the crown and main root. These larvæ possess well developed legs, while the genuine "strawberry root-borer" described later has no legs at all. The following table is given in the report mentioned above, to show the difference between the three kinds of root-worms, all of which occur in our state, but still devote their attention more to the wild strawberries than to the cultivated ones.

Synopsis of larvæ.

- I. Mandibles bifid at tip.
 - A. Inner edge of mandibles excavated before tip, anal segments shorter than preceding, ventral tubercles not prominent.....*Paria*.
 - B. Inner edge of mandibles not excavated, anal segments more developed than preceding, ventral tubercles prominent, with long hairs.....*Colaspis*.
- II. Mandibles entire at tip, inner edge excavated, anal segment short, ventral tubercles not prominent..*Graphops*.

Synopsis of pupæ.

- I. Anal hooks simple, incurved.....*Colaspis*.
- II. Anal hooks recurved.
 - A. Hooks short and stout, with strong erect tooth at upper side of base, and two long hairs on posterior margin*Graphops*.
 - B. Hooks slighter, simple, or with slender hair at upper side of base, no hairs on margin.....*Paria*.

"The three beetles mentioned above may be easily distinguished, the *Colaspis* being usually of a pale clay-yellow, ranging to a yellowish brown, smooth but not shining, concolorous throughout, or occasionally with the head and thorax green; while *Paria* is shiny black above, varying to brown, with four black blotches upon the wing-covers, but always with pale legs (and

antennæ); and *Graphops* is purple or green, with a bronzed metallic luster, and covered with a gray pubescence, of which both other species are destitute."

As far as the adults are concerned they do not feed alone upon the strawberries, but are rather general feeders. *Colaspis brunnea* feeds by preference upon strawberry leaves early in the season, but later becomes very destructive by eating the foliage of the wild and cultivated grape-vine, hence is frequently named "Grape-vine Colaspis." It also occurs upon the blossoms of clover and willow, and upon the leaves of many kinds of trees, as it is frequently beaten into umbrellas used to catch insects.

Paria species are also general feeders; they do not alone injure the leaves of strawberry, but those of raspberry and crab apple as well. Many other leaves are eaten, and even the needles of the Juniper are to their taste.

Graphops prefers the strawberry plants, but is also very partial to the evening primrose, as large numbers of these beetles are found on this plant.

The life-histories of these insects as far as known are curiously different in respect to the times and periods of their development. The larva of *Colaspis* appears early in the season, and does its mischief chiefly in the months of April and May, the beetles beginning to emerge in June. That the eggs are laid in the preceding year is highly probable, in which case the species hibernates in the egg.

Paria, on the other hand, certainly passes the winter as an adult, doubtless laying its eggs in spring, and making its principal attacks upon the plants in June and July, the beetles emerging in the latter part of July, and early in August.

Graphops hibernates in the larval condition, pupates in the spring, and emerges in May and June. The eggs are probably laid in July, and the larvæ make their attack upon the plant in August and September, continuing it possibly to October as well.

As larvæ all three prefer the strawberry roots and crowns, and as far as known depend strictly upon this food. If at all numerous they kill the infested plants very soon, since as many

as fifteen or twenty grubs have been found about the roots of a single plant.

The remedies suggested for the *Paria* are applicable to all. Prof. Forbes makes the following very practicable suggestion: "To rid a new field of strawberry plants it would be wise to allow the new runners to set, in case the new plants should be suspected of containing such root-worms, and then to destroy the recently planted stools from which they sprang, leaving the field stocked only with new stools, formed since the plants were set out."

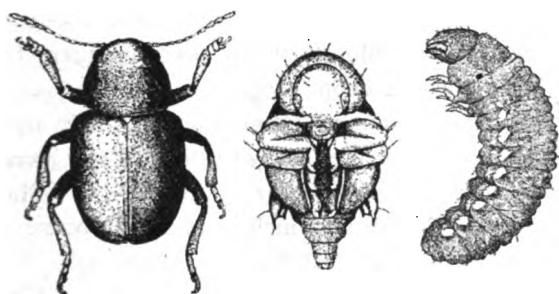


Fig. 147.—*Graphops pubescens*, Melsh,—After Forbes.



Fig. 149.—*Nodonota puncticollis*, Say.—After Division of Entomology, U. S. Department of Agriculture.

THE CLOAKED CHRYSOMELA.

(*Glyptoscelis crypticus* Say).

This is another beetle very similar to *Graphops pubescens*, but according to Prof. Saunders it devours the foliage of the apple-tree, as well as that of the oak. It is of a thick, cylindrical form, about one-third of an inch long, with its head sunk into the thorax, and the thorax narrower than the body. It is of a pale ash-gray color, entirely covered with short whitish hair. The closed wing-covers have a small notch at the top of their suture. At the junction of the wing-covers with the thorax there is a dusky spot. This insect is represented in Fig. 148.

THE PLUM LEAF-BEETLE.

(Nodonota tristis Ol.).

This oval beetle is of a shining, dark, metallic-blue, with legs and feelers yellow or chestnut brown; some specimens are bronzed, purplish, greenish, or even very dark brown. The thorax is densely punctuated with small dots. The damage they cause is not very great, although in the South they cause considerable injury by eating holes into the leaves of young plum trees; the peach and apple foliage is also to their taste, as well as that of the cherry, shad-berry, and choke-cherry, and Prof. Ashmead reports that they "gnaw little irregular holes into the blossoms and epidermis of the bolls of cotton, exposing them to the weather, and causing them to drop."

The beetles are not uncommon in Minnesota, especially upon apple trees, but they are not frequently seen, as they have the habit of hiding themselves in the folds of the leaves. The eggs are known, but not so the larvæ, which, very likely, possess the habits of related insects, i. e., are found among the roots.

A very similar beetle, (Fig. 149), the *Rose Leaf-beetle*, (*Nodonota puncticollis* Say), is also found upon the same kinds of plants, but seems to prefer the wild rose and blackberry; it also occurs on the young terminal leaves of willows, hence seems to be a general feeder. If at all numerous these beetles can be poisoned by means of the arsenites, and as they do not try to escape by flight they can be captured in large numbers by inverted umbrellas.

There are still other and similar small beetles which are more or less destructive to our fruit-producing plants, but none cause very serious losses, and then only at long intervals, when their number is increased by especially favorable climatic or other conditions.

Among the more typical leaf-beetles we have such forms as the well known *Colorado potato-beetle*, (*Doryphora 10-lineata* Say), originally a native of the Rocky Mountains, feeding in its old home on the sand-burr, (*Solanum rostratum*), a plant related

to the cultivated potato. As this beetle is not injurious to any of our fruit-producing plants, but confines its attention solely to such plants as the potato, egg-plants, tomato, ground-cherry and other members of the *Solanum* family, it is not necessary to describe it in detail, and only a picture of it is given to show how it differs from other leaf-feeding beetles. (Fig. 150 and 151, Plate II). This beetle commenced its migrations toward the east about the year 1859, reaching the Atlantic Coast about the year 1874. It moved from potato-field to potato-field, and as it had at first no enemies it increased most rapidly to destructive numbers. Now it has many foes among other insects, birds and mammals, and the farmers know quite well how to fight it by means of arsenical poisons. In fact the utility of Paris-green was first demonstrated by using it against this insect and its nasty looking larvæ.

Similarly shaped insects abound in Minnesota, but none are especially destructive, except, perhaps, the *Chrysomela exclamationis*.



Fig. 150.—*Doryphora 10 lineata*, Say.—After Brehm.

nonis Fab., a smaller yellowish-red beetle, marked with longitudinal black lines, the outer ones on each wing-cover being interrupted in such a manner as to look like an exclamation sign (!). The beetle is sometimes very numerous upon wild roses, destroying the flowers almost entirely. But as our wild roses in the prairies are decidedly a bad weed we should not complain even if it is a rose that suffers. *C. lunata* Fab., a peculiarly colored light brown beetle, marked with darker brown, has similar food habits.

Several other members of the genus *Chrysomela* are very destructive to willows in our wind breaks. All can be fought by the same means, i. e., Paris-green or London-purple; these arsenites should be used at the rate of one pound in from seventy-five to one hundred gallons of water, and applied by machines, of which many very effective and cheap ones, especially constructed



Fig. 152.—*Lina tremulae*, Fab.—After Brehm.

for this purpose, are in the market. But it should be recollected that the spraying should be done as soon as the beetles begin feeding in spring, so as to kill the adults before they have deposited their eggs. Our people usually wait until the damage caused by all kinds of insects becomes plainly visible, which is not a wise thing to do, as in such a case the application of the arsenites will simply check the trouble; the proper way to do is to nip the evil in the bud, and to do so an early warfare is absolutely necessary.

The very similar genus *Lina* also contains numerous very destructive beetles, which, however, devote all their attention to devouring the foliage of willows and poplars, in which they succeed only too well, as may be seen in some wind-breaks, which are defoliated year after year by these and some other insects, and to such an extent that they are as bare of green leaves in summer as during the winter. A timely application of arsenites would prevent this injury, which, repeated year after year, can result in but one way, the death of the infested plants. It seems as if many persons did not know the old proverb "an ounce of prevention is worth a pound of cure."

One species of *Lina* (*L. tremulae* Fab.), exceedingly abundant and injurious in the north, is illustrated in Fig. 152, and a still more destructive kind, the *L. scripta* Fab., in Fig. 153. It sometimes devours all the leaves of willows in our wind breaks.



Fig. 153.—Varieties of *Lina scripta*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

There is another small group of leaf-feeding beetles called the *Diabroticas*. They are rather slender and soft, with long feelers; their color is green or yellow, with black spots or lines. Prof. Smith, in his book already mentioned, gives the following account of them :

"The adults feed on leaves, flowers or pollen, but the larvæ, which are white and slender, usually feed in the roots and stems of plants. One of our most common forms, (*Diabrotica vittata* Fab.), is known as the "striped cucumber-beetle," and is yellow with black stripes on the wing-covers. It feeds on all kinds of cucurbit vines, and on many other plants as well; it does injury by eating into the stem of the young shoot at or below the surface, where it has a tendency to hide during the middle of the day. The larvæ, (Fig. 154), live in the main roots under ground, making short galleries, which, if numerous, weaken or even kill the plants. The beetles winter as adults. A free use of tobacco

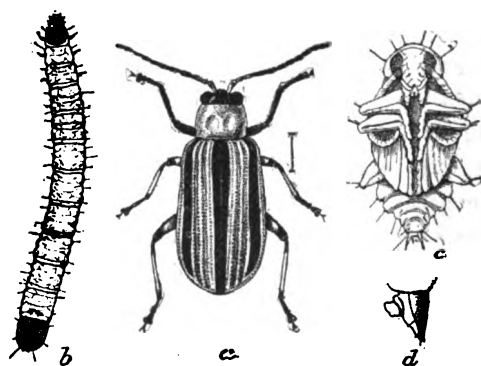


FIG. 154.—*Diabrotica vittata*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

dust around young vines or other injured plants is usually protective, though in some localities the farmers resort to "driving." They do this before the middle of the day, sowing air-slaked lime with the wind, and this seems to be sufficiently offensive to the winged insects to induce them to leave for fields to the leeward, where they of course become doubly injurious unless also driven off. Planting an excess of seed to distribute the injury is common practice, and so is starting the plants in baskets and setting them out when well established and able to resist injury.

"Melon and other cucurbit vines should always be plowed out, raked up, and destroyed as soon as possible after the crop is off, to destroy any larvæ that may then be in the roots."

It is also a common and very effective practice to cover young plants with a mosquito-netting, held in position by a slight frame.

Such beetles are not unfrequently found in the flowers of apple or plum, and they are there for no good purpose.

An allied and equally common species feeding upon a great variety of plants as an adult, is the *D. 12-punctata*, Oliv. or "12-spotted Diabrotica," (Fig. 155). This is somewhat larger than the preceding, with a more oval body, and has twelve black spots on the greenish-yellow wing-covers. The larva feeds on a variety of plants, and becomes injurious to the corn in the Southern States. There are two broods, the beetles wintering in the adult

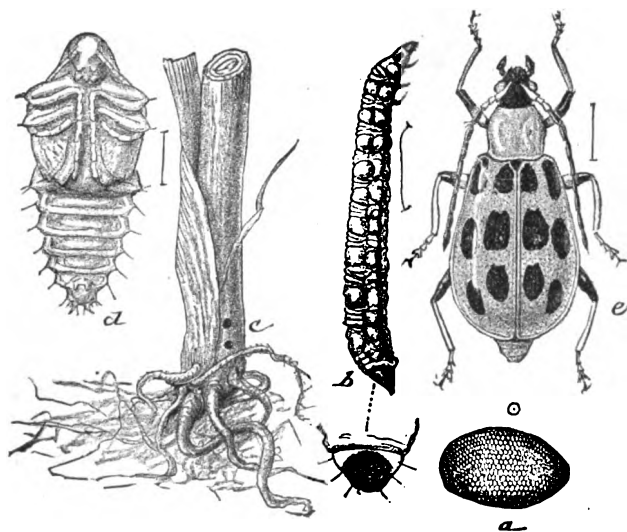


Fig. 155.—*Diabrotica 12 punctata*, Oliv.—After Division of Entomology, U. S. Department of Agriculture.

stage. No direct remedy is known, but good cultivation and a liberal application of stimulating fertilizers is advisable to enable the corn-plant to resist and outgrow attack. Clean culture is the greatest essential, and this of itself will do much to reduce injury.

In the Western and Central States a third species (Fig. 156) is found, the "Corn-root *Diabrotica*," (*D. longicornis* Say),

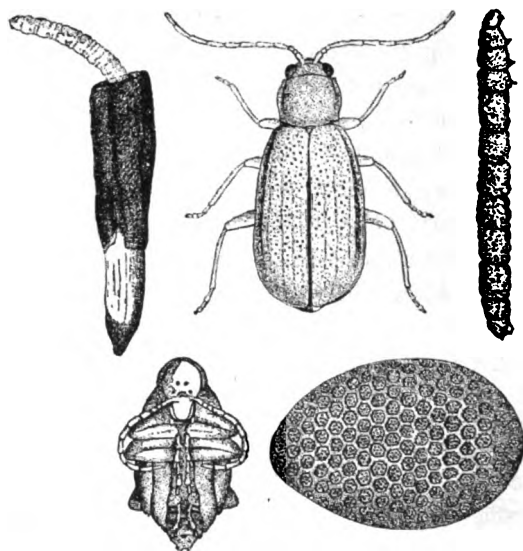


Fig. 156.—*Diabrotica longicornis*, Say.—After Forbes.

named so from its long feelers. Its larva is a very serious pest. As this species winters in the egg stage in corn-fields a simple rotation is all that is necessary to keep it in check. It is not found in Minnesota, at least no specimens have been seen or received, while the two species already described are very common, and the striped kind seems to be rapidly on the increase.

The genus *Galeruca*, as well as some closely allied other genera, contain a series of small oblong beetles, mostly of a dirty clay-yellow color, more or less spotted or marked with black. Some of these beetles are very destructive, not alone to shade-trees, but to fruit-trees as well.

THE CHERRY LEAF-BEETLE.

(*Adimonia femoralis* Melsh.).

In a number of states this beetle has caused considerable injury to the leaves of plum, cherry, and peach. Its natural food is the leaves of the native plum, into which it eats numerous holes. In Minnesota it is common enough in many localities, especially in

the burned region about Hinckley, where the "fire cherry," (*Prunus pennsylvanica*), has taken full possession of the ground. It may be simply a question of time before it attacks the cultivated trees in our orchards as well.

The beetle is a small insect, measuring less than a quarter of an inch in length, and is of a bright red color, with feelers, eyes, and exterior portions of the legs black. It is densely covered with a coarse punctuation, the punctures being separated by distinct intervals; the surface is shiny. Such beetles are most abundant during June or early July, and again in September; those appearing in June seem to represent the hibernated generation, those appearing later are their progeny. As such beetles have been repeatedly found along the edges of woods early in April, there can be no doubt that they hibernate as perfect insects.

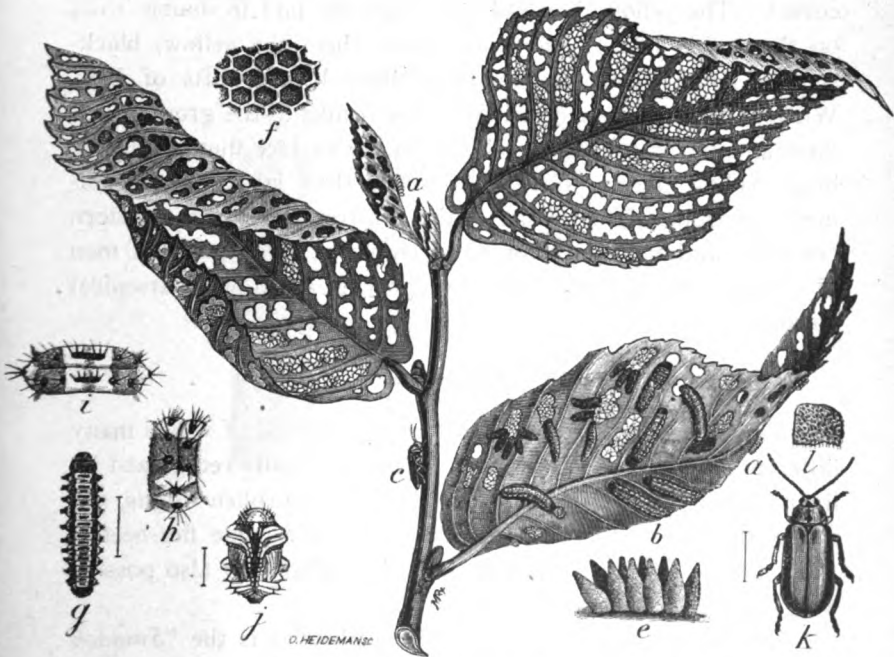


Fig. 157.—*Galeruca xanthomelana*, Dalm.—After Division of Entomology, U. S. Department of Agriculture.

The egg is oval, bright straw-yellow, the surface deeply pitted with minute, rather irregular six-sided areas. The larva is about 5 mm. long, narrow, and tapering toward the end. According to Mr. Davis, it has the head, legs, pronotum and terminal plate black; on the back of each segment are two transverse rectangular dark spots, with two or more smaller ones on the sides of the larger two, and beneath them there is a longitudinal block on each segment. The venter of each abdominal segment is marked with five dark brown spots, the central one being largest. These larvæ also feed on the leaves of the cherry.

To show the general appearance of insects of this group of beetles, the "*Elm-leaf beetle*" (*Galeruca xanthomelaena* Schr.), is illustrated in Fig. 157. It is happily not found in Minnesota, at least none have been seen or received thus far; it is another of the many undesirable insects imported from Europe. It is greenish-yellow when fresh, with two black stripes on the wing-covers. The yellow, bottle-shaped eggs are laid in double rows on the under side of leaves and from them the yellow, black-spotted larvæ hatch, covered with little bristly tufts of hair. When full grown they crawl down the trunks to the ground, and there among the grass and rubbish on the surface they change to bright-yellow pupæ. These beetles and their larvæ are exceedingly injurious to the foliage of the elm trees, and in the eastern cities the authorities are forced to employ a large gang of men to protect and save the trees by spraying them with arsenical poisons.

FLEA-BEETLES.

This is another group of leaf-feeding beetles, of which many different kinds occur in our state. They are easily recognized by their hind legs, which possess very large and swollen thighs, enabling the insects to leap like fleas, hence the name flea-beetles (Fig. 158). But they differ from fleas in that they also possess wings as well, which are readily used.

One of the best known of such flea-beetles is the "*Sumach Flea-beetle*" (*Blepharida rhois* Forst.), which is exceedingly



Fig. 158.—Flea beetles.—After Brehm.

numerous in our parks and along the edges of forests, or wherever the sumach grows. Here the filthy larvæ, filthy because they cover themselves with black and slimy pellets of their own excrement, frequently devour all the leaves of these showy bushes, and instead of being ornamental they become a decided eyesore to the

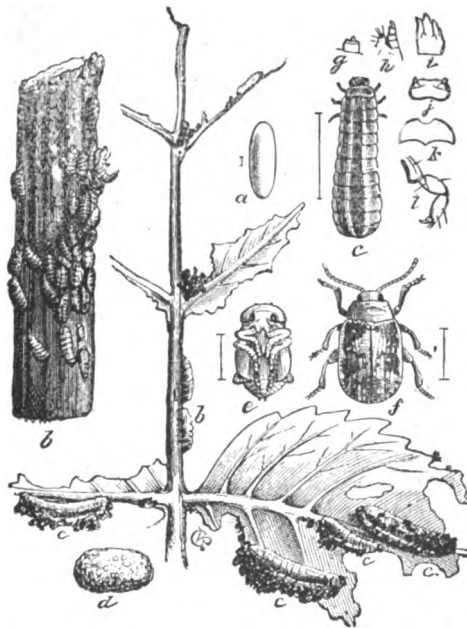


Fig. 159.—*Blepharida rhois*, Forst.—After Riley.

lover of plants and the admirer of well kept parks. This largest of our North American flea-beetles is shown in all stages in the illustration (Fig. 159). It is a rather convex beetle, differing greatly in this respect from other flea-beetles, which are usually very much flattened. The color of the beetle is a greenish-yellow,

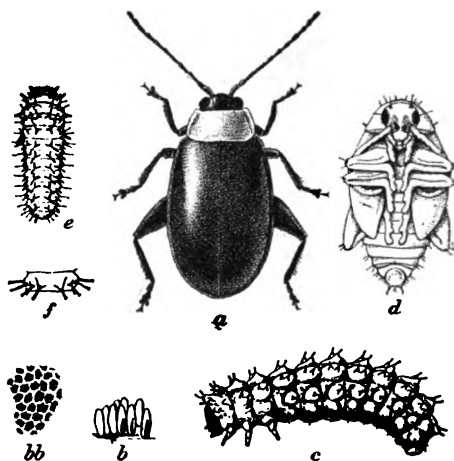


Fig. 161.—*Dionycha xanthomelena*, Dalm.—After Division of Entomology, U. S. Department of Agriculture.

and the wing-covers are marked with dark brown lines and dots.

Our Minnesota fauna is rich in flea-beetles. Some quite large ones are found upon willows; they are usually yellow, with broad or narrow black longitudinal lines upon their wing-covers;

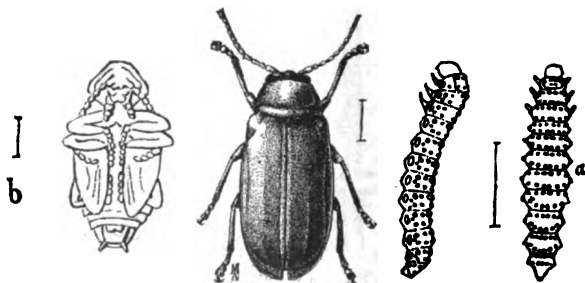


Fig. 162.—*Haltica blmarginata*, Say.—After Division of Entomology, U. S. Department of Agriculture.

the pro-thorax is in most cases ornamented with a number of dark spots arranged symmetrically. One kind of such beetles is frequently found squatting on the dry sidewalks very early in spring, as if enjoying the warm rays of the sun. If touched it disappears as if by magic, doing so by means of its powerful hind legs, which enable it to leap very long distances. One of these beetles is illustrated in Fig. 160; it is *D. xanthomelaena* Dalm.

A dark steel-blue species of the genus *Haltica*, (*H. bimarginata* Say), is sometimes exceedingly numerous and destructive to the willows growing upon the shores of our lakes, hence becomes to a certain degree injurious. It is shown in Fig. 162.

But not all flea-beetles are satisfied with such food, and to the great sorrow of fruit-growers some show a most decided love and preference for the foliage of fruit-producing plants.

THE GRAPE-VINE FLEA-BEETLE.

(*Haltica chalybea* Ill.).

This little beetle, very uncommon until the last season, has in some places become a very destructive pest to wild and cultivated grapes. It commences its operations very early in the season, and indicates its presence before long by eating the substance of the buds as soon as they begin to swell, thus destroying many bunches of grapes in the embryo. Prof. Saunders describes its life-history as follows:

"It goes on with this work for about a month, when it gradually disappears. Before leaving, however, the beetle provides for the continuance of its race by depositing little clusters of orange-colored eggs on the under side of the young vine leaves, which, in a few days, produce colonies of small, dark-brown larvæ, which feed on the upper side of the leaves, riddling them, and when numerous they devour the whole leaf except the larger veins, and sometimes entirely strip the vines of foliage. Fig. 163 represents the larvæ in various stages of growth at work on the vine, accompanied also by some of the beetles.

"In two or three weeks the larva attains its full growth, when it is a little more than three-tenths of an inch long, usually

of a light-brown color, sometimes dark, and occasionally paler and yellowish. The head is black, and there are six or eight shining black dots on each of the other segments of the body, each dot emitting a single brownish hair. The under surface is paler than the upper; its feet, six in number, are black, and there is a fleshy, orange-colored proleg on the terminal segment.

"When mature the larvæ leave the vines and descend to the ground, where they burrow under the earth, and form small, smooth, oval cells, within which they change to dark-yellowish

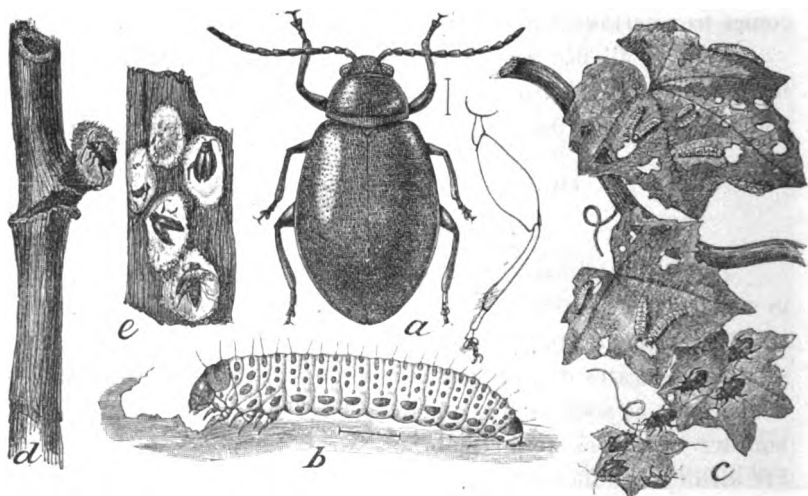


Fig. 163.—*Haltica chalybea*, Ill.—After Division of Entomology, U. S. Department of Agriculture.

pupæ. After remaining two or three weeks in this condition, the beetles issue from them, and the work of destruction goes on; but since they live altogether on leaves at this season of the year, of which there is an abundance, the injury done is much less than in the spring.

"The beetle is about three-twentieths of an inch long, and varies in color from a polished steel-blue to green, and occasionally to a purplish hue, with a transverse depression across the hinder part of the thorax. The under side is dark green, the antennæ and feet are brownish-black; the thighs are stout and ro-

bust, by means of which the insect is able to jump about very nimbly. One of the legs, detached from the body, is shown in Fig. 163.' On the approach of winter the beetles retire to some suitable shelter, as under leaves, pieces of bark, or in the earth immediately around the roots of vines, where they remain inactive until the following spring. In addition to the grape-vine they feed on the Virginia Creeper, (*Ampelopsis quinquefolia*), and the alder, (*Alnus serrulata*), and sometimes eat the leaves of the plum tree.

"Remedies: To destroy the beetles it is recommended to strew air-slaked lime or unleached ashes around the infested vines in the autumn, removing and destroying all rubbish which might afford shelter. In the spring the canes and young foliage may be syringed with water in which a teaspoonful of Paris-green has been stirred to each gallon. Strong soap-suds have also been recommended, and are deserving of trial. On chilly mornings the beetles are comparatively sluggish and inactive, and may then be jarred from the vines on to sheets and collected and destroyed. These insects are much more abundant in some seasons than in others."

THE LESSER GRAPE-VINE FLEA-BEETLE.

(*Haltica ignita* Ill.).

This little beetle, not much more than half the size of the one described above, varies greatly in different portions of the Union, even in different parts of the same state. It is polished greenish-blue, dark blue, purplish-blue, copper-colored, or even brassy. All those found in Minnesota are dark blue, with a light tinge of purple. Their habits are identical with those of *H. chalybea*, hence it is not necessary to describe them. They were first noticed by Mr. J. W. Taylor, who resides near White Bear Lake, early in the spring of 1899, eating into the buds of wild grapes; soon afterwards they attacked his cultivated varieties, and later the foliage of the Virginia Creeper. Their work is shown in Fig. 164, Plate VI. After destroying the buds they continued

their work upon the fully expanded leaves, which were riddled in every conceivable manner to such an extent as to destroy them entirely. At least two generations did damage. The hibernating beetles commenced the work, and soon after their appearance numerous eggs were found among the woolly substance of the partly destroyed buds. The larvæ soon hatched and continued the work, and after passing the pupal stage in a small earthen cell in the ground, a new generation of beetles appeared, which did not disappear until the beginning of the warm weather in summer, evidently to pass the rest of the warm season and the winter in or near the ground.

It is somewhat difficult to ascertain the number of broods in this case, as some of the adults lived for a long time, and were surrounded by other beetles, their own progeny.

This species promises to become decidedly injurious, and wherever it is found should be fought with arsenites as soon as noticed.

This is especially important, and most successful in the spring when the culprits are still confining their attention to the buds. A very strong arsenical mixture, one pound to fifty gallons of water, with lime to prevent injury to the plant, has afforded good protection.

THE APPLE-TREE FLEA-BEETLE.

(*Haltica foliacea* Lec.).

This is another little flea-beetle about the size of *H. chalybea*, but slightly more elongated, and of a highly polished brassy-green color. The feelers are dull brownish-black beyond the three basal joints, which are obscured by short fine hairs; the feet are also dull brownish and pubescent.

This beetle is not common in Minnesota, having been found only in the southwestern part of the state, where it occurred rather abundantly feeding upon the evening primrose, the leaves of which were entirely riddled by it. It was found also upon similar plants growing near the shores of White Bear Lake, and Lake Minnetonka, as well as in Brookings, South Dakota. thus

showing that it may be much more generally distributed in our state than is suspected. In Missouri, Kansas, Nebraska, and Colorado it is a bad insect, especially so in nurseries, where it riddles the leaves of the apple with small irregular perforations.

Miss Mary E. Murtfeldt, whose work in entomological investigations is so well and favorably known, has published the following notes on the habits of this beetle in "Insect Life":

"I placed my beetles, received from Colorado, on fresh apple leaves and awaited developments. More than a month elapsed before I found eggs in the jar. On the 9th of July I found several clusters attached to the stems and bases of the midribs of the leaves. They are generally in twos and threes, ranged side by side. They are about 1 mm. in length, oblong rather than oval, and of a pale, dull orange color, somewhat translucent, and Prof. Popenoe, who has also obtained them, says that under a high magnifying power the shells are seen to be minutely granulated.

"By the 17th of July a number of larvæ had hatched. They are nearly cylindrical, of a dull black color, and rather more elongate in proportion to their diameter than the larvæ of *H. chalybea*. When grown they feed on the parenchyma of the leaf, indifferently on either surface, but later they gnaw holes in it similar to those made by the perfect beetle. The first molt took place in eight days, and two or three of the small larvæ perished in the process, being unable to entirely withdraw themselves from the outgrown skins. The second molt occurred one week later, and in this also one larva perished. During these periods there are no changes of color or maculation. August 2nd one larva had completed its growth, and as it was making its way into the earth, I put a stop to its further development by transferring it to the alcohol bottle. The following characters are noted: length of mature larva from six to seven mm., diameter one and one-half mm.; form cylindrical, tapering somewhat posteriorly; general color varying from dull black to dark fuscous, piliferous plates inconspicuous, of the same shape, number and arrangements as those of *H. chalybea*, black in color, but slightly polished, each giving rise to from one to three minute hairs, head roundly

cordate, deep black, but not brilliantly polished, pro-legs well developed, faintly annulated at the joints with dingy white. The larvæ move about considerably, but in a slow and rather clumsy fashion, with the tip of the abdomen appressed to the surface of the leaf or stem to assist in keeping them in position.

"The pupa is enclosed in a frail earthen cocoon or cell, just beneath the surface of the ground. The pupal stage lasts only two weeks, when the adults make their appearance. The insect is also double brooded, the last generation passing the winter in the ground."

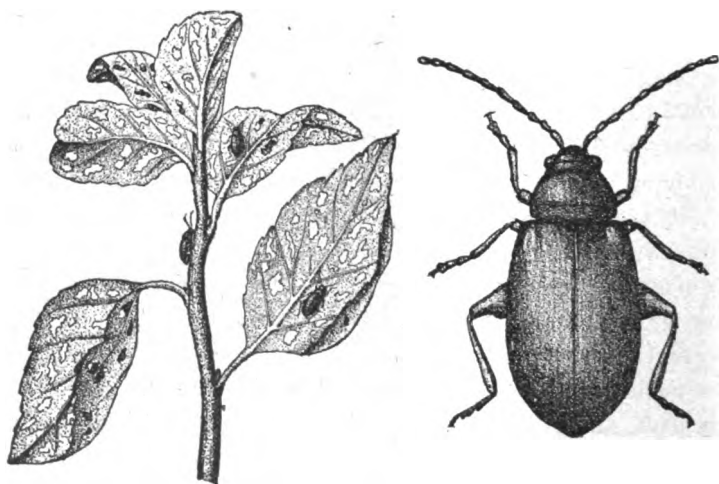


Fig. 165.—*Haltica foliacea*, Lec.—After Marlatt.

As this beetle, Fig. 165, is apt to become a serious enemy to our nurseries, their owners should be on the lookout to destroy it as soon as it is noticed. It seems to be changing its habits, deserting its normal food to become an enemy to cultivated plants.

As far as remedies are concerned, the experiments of Prof. Popenoe, of Miss Murtfeldt, and of Prof. Bruner are quoted: Beetles like the three species just described, can be successfully jarred into cloth collecting frames, and if these are saturated with kerosene, the beetles striking them will not be able to fly away, but will perish.

There are still other and still smaller flea-beetles which riddle the leaves of apple trees with small holes, but the damage is slight, since such insects as a general rule prefer other plants for food.

THE SMALL WILLOW FLEA-BEETLE, (*Crepidodera Helxines* Linn.), a very common insect, eating the foliage of most of our narrow-leaved willows, has been repeatedly found towards the end of June engaged in doing similar work on that of the apple. It is one of the most variable beetles we have, at least so far as colors are concerned, and numerous varieties have been made on that account. It is usually, however, of metallic green, blue, coppery or golden. As a general rule all leaf-feeding beetles distinguished by metallic colors vary greatly in this respect. This beetle is still smaller than *H. ignita* mentioned before. *C. rufipes* Linn., illustrated in Fig. 166, gives a good idea of how such insects look.



Fig. 166.—*Crepidodera rufipes*, Linn.—
After Division of Entomology, U. S.
Department of Agriculture.

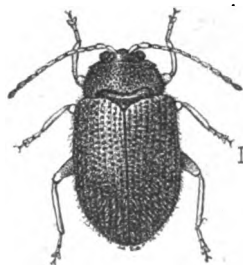


Fig. 167.—*Epitrix cucumeris*, Harr.—
After Division of Entomology, U. S.
Department of Agriculture.

A still smaller flea-beetle, the *Cucumber Flea-beetle*, (*Epitrix cucumeris* Harr.), and the closely allied *E. fuscula* Crotch, are also found eating holes in the leaves of apples. As the former one is a very destructive beetle to all plants belonging to the botanical order *Solanaceae*, it is illustrated in Fig. 167. The name "Cucumber Beetle" is surely a misnomer, since notwithstanding its omnivorous habits it is practically confined to the above order of plants. The beetles are chiefly destructive to tomatoes, potatoes,

tobacco, egg-plants, and pepper, and can cause considerable mischief to the young and tender plants, into which they eat numerous holes.

The beetle is very small, black, covered with rather thick hairs; the feelers and legs are reddish-brown. It is a very active being, and one very difficult to capture, being as agile as a healthy and vigorous flea. In the larval stage it feeds chiefly in the roots of the tomato.

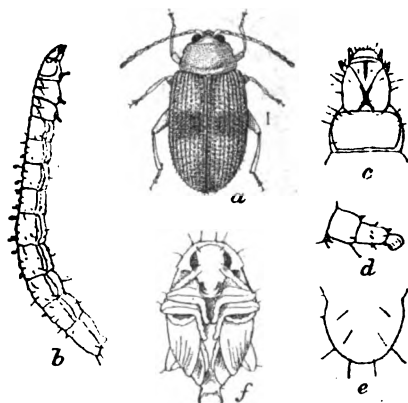


Fig. 168.—*Epitrix parvula*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

E. fuscula Cr., has once been very destructive in hot-house frames, in which it killed numerous small egg-plants; *E. parvula* Fab., so destructive to tobacco in the southern states, is shown in Fig. 168.

As far as remedies are concerned, Paris-green and London-purple are satisfactory remedies, and it has also been observed that the Bordeaux mixture, used against certain diseases of plants, when liberally used, acts as a deterrent, and thus serves a double purpose. If poisons can not be used a decoction of tobacco is of great benefit, at least if we have to use it only on a small scale.

THE RED-HEADED SYSTEMA.

(Systema frontalis Fab.).

This common flea-beetle has repeatedly caused injury to the grape-vines by eating the green tissues on the upper sides of the leaves, which in consequence discolor and wither. Like the other flea-beetles it possesses enormous leaping powers, and as it is rather large and very agile, it is no easy matter to capture it. It is about one-sixth of an inch long, with densely, but very finely punctured thorax and wing-covers. The head is reddish-yellow above, especially in front and between the eyes; the long feelers are also reddish, with black basal joints; the underside is brownish-black. Equally common is *S. hudsonias* Fab., which is entirely black, with dark rusty-brown feelers and legs.

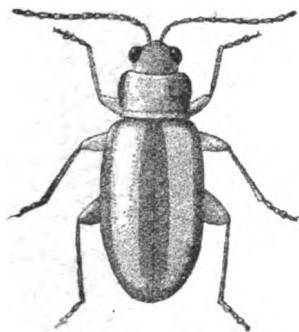


Fig. 169.—*Systema taeniata*, Say.—
After Forbes.

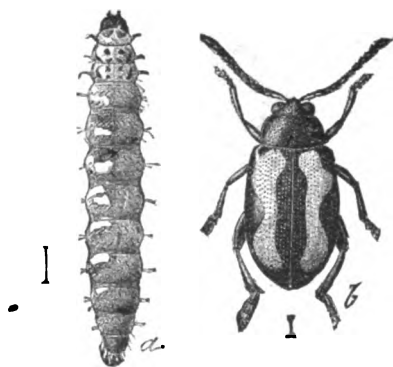


Fig. 170.—*Phyllotreta vittata*, Fab.—
After Division of Entomology, U. S.
Department of Agriculture.

Another species of *Systema*, illustrated in Fig. 169, is decidedly injurious to the young plants of the sugar-beets. It is called the "pale-striped flea-beetle" (*S. taeniata* Say), and is here illustrated to show the shape of insects of this kind.

Among the large numbers of injurious flea-beetles at least one other should be mentioned, as it is frequently received as being very destructive to a number of young plants, but chiefly to plants belonging to the *Cruciferae*, as cabbage, radish, mustard, and oth-

ers. The "Wavy-striped flea-beetle," (*Phyllotreta vittata* Fab.), is illustrated in Fig. 170. It is a minute, shiny black insect, with a distinct yellow stripe through the middle of each elytron. The larvæ make mines into the tissues of the plants mentioned above. As a remedy it is important to keep down all cruciferous weeds, in other words to give the land a clean culture, and to remove the remnants of the crop as soon as possible and to destroy them. The adult becomes even more injurious by eating little pits into the thicker leaves, and minute holes into the thinner-leaved plants they infest; in such cases the use of arsenites or of kerosene-emulsion is of great benefit.

According to Prof. Saunders this beetle is also sometimes found to eat the leaves of strawberry plants.

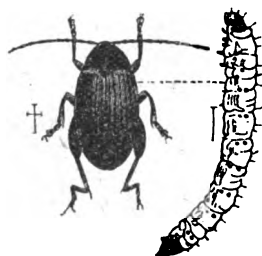


Fig. 170 1/2.—*Psylliodes* species.—After Brehm.

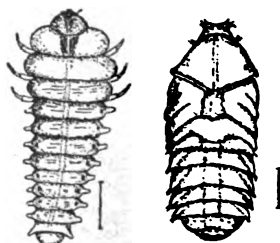


Fig. 171.—*Oiontota dorsalis*, Thunb., larva and pupa.—After Hopkins.

Numerous other flea-beetles belonging to the genus *Psylliodes* occur in Minnesota; one of which is shown in Fig. 170 1/2.

A small number of very curiously shaped beetles follow the flea-beetles in the classification of beetles usually adopted. They are wedge-shaped beetles, or *Hispidae*, in which the antennæ are thickened, and the elytra broadened at the tip, where they terminate rather abruptly. In most of these brightly colored beetles the body is much roughened by deep furrows and pits. These and the tortoise beetles, which follow next, also differ from other leaf-feeding beetles in having the fore part of the head prominent, so that the mouth-organs are situated on the underside.

The larvæ of *Hispidae* are leaf-miners; the eggs are covered with a little mass of excrement, and are laid singly. None of the beetles are very injurious, with perhaps the exception of the "locust-beetle," (*Odontota dorsalis* Thunb.), which is orange in color, with a broad black stripe along the suture of each elytron. Sometimes this species is so abundant early in summer, on the leaves of the locust, as to cause considerable injury, but as the beetles feed exposed they succumb readily to an application of the arsenites. The larva and pupa of this beetle are shown in Fig. 171.

According to Prof. Comstock the larva of *O. rubra* Web., a beetle from one-eighth to one-fifth of an inch long, of a reddish color, with the elevated portions of the elytra more or less spotted with black, mines in the leaves of apple, forming a blotch-mine. The transformations are undergone within this mine, which is also formed in great numbers on the leaves of linden or basswood.

THE ROSY HISPA.

(*Odontota nervosa* Panz.).

This is a much smaller species, flat, rough, coarsely punctuated, the wing-covers forming an oblong square, as shown in Fig. 172. There are three smooth, raised longitudinal lines, spotted with red, on each of them, while the spaces between them are deeply pitted with double rows of dots. The head is small, the feelers short, thickened towards the end, and the thorax is rough above, and striped with deep red on each side. The under side of the body is usually darker in color, sometimes blackish. This species varies a good deal, not alone in size, but also in color and markings, and formerly a number of species had been made of it, one of which, (*O. inaequalis* Web.) is very dark, almost uniformly brownish-black, with some lighter spots and lines. The beetle is found from the latter part of May until the middle of June, and deposits its eggs on the leaves of the apple tree.

According to Prof. Saunders, "they are small and rough, and of a blackish color, fastened to the surface of the leaves sometimes singly, and sometimes in clusters of four or five.

"The larvæ when hatched, eat their way into the interior of the leaf, where they feed upon its green pulpy substance, leaving the skin above and below entire, which soon turns brown and dry, forming a blister-like spot. The larva, when full-grown, which is generally during the month of July, is about one-fifth of an inch long, oblong in form, rather broader before than behind, flattened, soft, and of a yellowish-white color, with the head and neck blackish and of a horny consistence. Each of the three anterior segments has a pair of legs; the other segments are provided with small fleshy warts at the sides, and transverse rows of little rasp-like points above and beneath.

"The larva changes to a pupa within the leaf, from which, in about a week, the perfect insect escapes. Within these blister-like spots the larva, pupa, or freshly transformed beetle may often be found."



Fig. 172.—*Odontota nervosa*, Panz.—
After Harris.

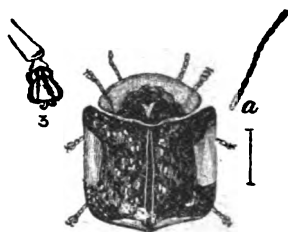


Fig. 173.—*Coptocycla clavata*, Fab.—
After Riley.

This interesting beetle is quite common in Minnesota, and occurs also in regions where no apples grow, hence it must be able to make mines in other plants as well. The adult beetle hibernates, and is frequently found among dead leaves and rubbish covering the ground along the edges of forests.

THE TORTOISE-BEETLES.

These remarkable beetles contain species that are among the most beautiful of all insects, being green, golden, or iridescent. Some in the tropics are so brilliant that at one time it was stylish to use them for jewelry. Although not injurious to fruit-produc-

ing plants they are so curious, and so often mailed as "gold-bugs" to the entomologist, that a few words about them may not be amiss.

In these beetles the ovate and almost quadrate body is flattened below and convex above; the head is nearly or quite concealed beneath the prothorax and the margins of the latter and of the elytra are broadly expanded, in some cases forming an almost circular outline, and in this way resembling the shell of a tortoise. This resemblance is heightened in at least one case, (*Coptocycla clavata* Fab.), by four dark projections of the central dark color of the wing-covers, which marks look like the broad legs of a turtle (Fig. 173). In another case (*C. guttata* Oliv.), only the front legs of a turtle are painted upon the frontal sides of the elytra.

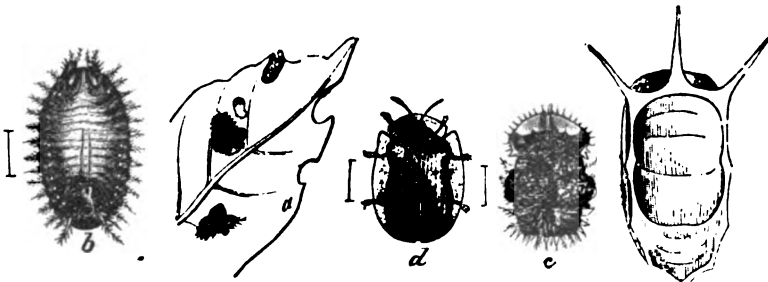


Fig. 174.—*Coptocycla bicolor*, Fab.—After Riley.

As already mentioned these beetles, when happy, are of brilliant colors, sometimes ornamented with black spots or longitudinal lines. One of our most common species, the *Cassida bicolor* Fab., (Fig. 174), so destructive to morning-glories and sweet-potatoes, is, during its wedding season, like a drop of burnished gold, which towards night is apt to fade to a peculiar pearly luster. Unfortunately such colors are not "fast," but disappear after the death of the insect. It is even claimed that the bright colors of these insects are dependent upon the emotions of the beetles.

Although the beetles are very beautiful, the larvæ are as nasty; they are flat, with long spines along the margins, and in addition they possess a forked appendage at the posterior end, which serves a very filthy purpose. It is bent forward over the back, and to it are attached the cast-off skins of the larva and also its excrement. The fork carrying such material is borne like an umbrella. In New Jersey, Maryland, and Virginia, where these insects abound in the sweet-potato fields, the larvæ have received the name "peddlers," since they carry a "pack." When ready to change to a pupa the larva fastens the posterior end of its body to the underside of a leaf, and now the skin splits open, and is forced back, exposing a pupa, which soon gives forth a beetle. Wherever such beetles are numerous the young plants of the sweet-potato should be dipped into arsenate of lead before they are set out. The solution should be fifteen ounces to fifty gallons of water.

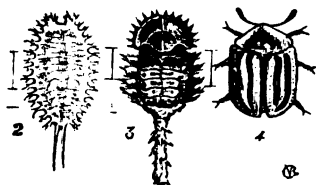


Fig. 175.—*Cassida bivittata*. Say.—
After Riley.



Fig. 176.—*Chelymorphism argus*, Licht.—
After Packard.

In Minnesota we have a number of such tortoise beetles, some very large, and also some that are found on other plants than those belonging to the family of *Convulvulaceae*, as the nettle and sunflower. *Cassida bivittata* Say (Fig. 175) frequently destroys the foliage of the beautiful morning-glory, and the much larger *Chelymorphism argus* Licht. (Fig. 176) is frequently found on the raspberry.

FAMILY BRUCHIDAE.

(*Pea-weevil family*).

These well known beetles, so destructive to many kinds of stored seeds of leguminous plants, as peas and beans, are not

injurious to any fruit-producing plants. They agree with the leaf-beetles in general structure, but their small head is prolonged into a broad beak and the wing-covers are rather short, not covering the tip of the abdomen. As an example of these beetles the *Bean-weevil* (*Bruchus rufimanus* Sch.), and the *Pea-weevil* (*B. pisi* Linn), are illustrated in Fig. 177. This pest can be controlled, even when still enclosed in the seed, by means of bisulphide of

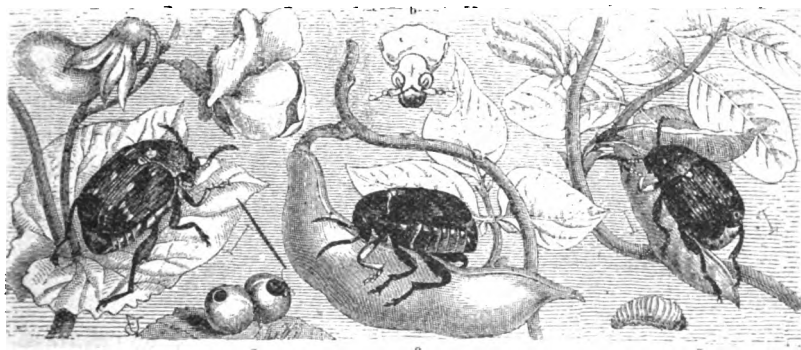


Fig. 177.—*Bruchus rufimanus*, Sch., and *B. pisi*, Linn. After Brehm.

carbon, the seeds being kept in a tight receptacle for this purpose. It should be the rule of every farmer to plant only sound seeds, and not to throw away any "buggy" peas, but to destroy the insects in them by boiling, when both peas and weevils can be fed to animals.

2. HETEROMERA. (Different Joints).

As already mentioned we find the chief peculiarity of the beetles in this group in the feet, the front and middle pairs of which are five-jointed, and the hind pair four-jointed; the joints of the tarsi are not cushioned beneath, as are those of the leaf-beetles. Many peculiar insects belong to this division, not alone peculiar on account of their shape, but also on account of their peculiar development, which has one or two seemingly retrograde stages in some species having parasitic habits.

FAMILY TENEBRIONIDAE.

(Darkling Beetles).

Nearly all the members of this family are of a uniform black or brown color, although some are gray, and a few are marked with bright colors. There is no uniformity in appearance, but in most cases the feelers are more or less bead-like or moniliform. They vary very considerably in size and form of the body, which is firm, and not soft as in the case of the blister-beetles mentioned later. Darkling-beetles are most numerous in dry and warm regions, but we also possess a fair representation in Minnesota, and some of them are altogether too numerous and injurious. Nearly all feed upon dry vegetable matter, some few on partly decomposed matter, and still others under stones, under bark of trees, and on fungi. But few are injurious to our fruit-producing plants.

As examples of such beetles a few of the more common and destructive ones will be given and illustrated.

THE MEAL-BEETLE, (*Tenebrio molitor* Linn.), Fig. 178, is a very common insect in our mills, stables, grocery-stores, pan-

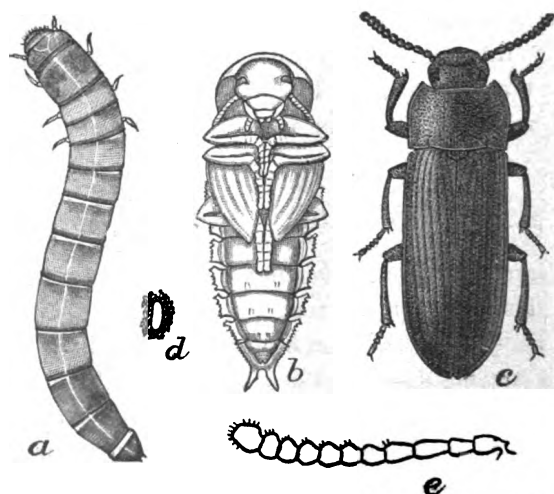


Fig. 178.—*Tenebrio molitor*, Linn.—After Division of Entomology, U. S. Department of Agriculture.

tries, in fact in all dark places where flour and meal is kept for a long time. These insects cause no serious injury, but are far from pleasant to have around. Their larvæ, best known by the name of "meal-worms," are sometimes bred purposely by bird-fanciers as winter food for insectivorous singing-birds; they are raised in immense numbers in warm boxes partly filled with bran, and in such places they undergo all their metamorphoses.

The beetles themselves are brownish, flattened, with a square thorax and deeply ridged wing-covers. The larva is a cylindrical, hard-shelled worm, usually of a polished waxy yellowish-brown

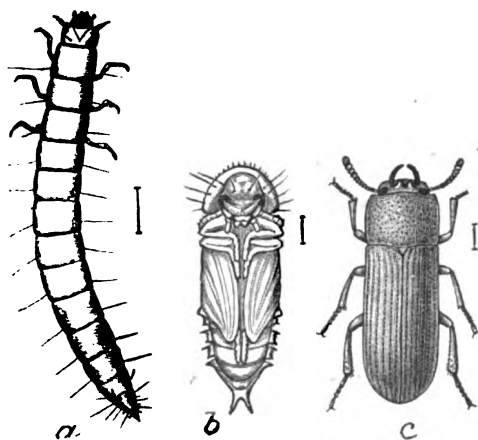


Fig. 179.—*Echocerus maxillosus*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

color, and terminates in a two-pointed posterior segment; it resembles the larva of the wire-worm in many ways, but is very much stouter.

A dark, almost black and more opaque beetle is the *T. obscurus* Fab., which is found in similar locations. Both are pests of granaries and mills, and are found in almost every region of the globe, being carried there by commerce.

A much smaller species, the *Echocerus maxillosus* Fab., is shown in Fig. 179. It is of a brown color, and further south is equally as much at home in old and neglected flour.

Cleanliness is one of the best remedies against such nocturnal insects. In extreme cases the fumes of bisulphide of carbon should be employed to kill them. Many of these and similar beetles have become very numerous in our houses since the introduction of prepared breakfast foods; the spaces behind the patent flour bins in pantries are also excellent breeding places for such insects, as there they are not as often disturbed as they ought to be.

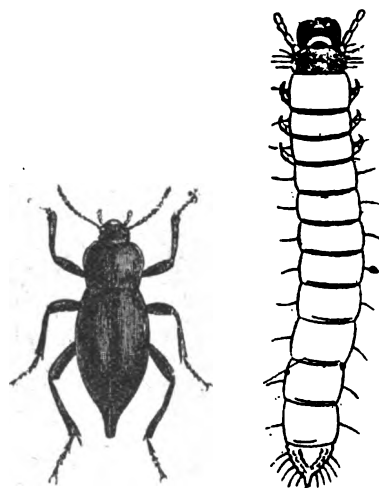


Fig. 180.—*Blaps mortisaga*, Linn., and larva. After Brehm.

Fig. 180 shows a common beetle belonging to this family; it is *Blaps mortisaga*, and is found in Europe, like the meal-bug, in barns, stables and cellars. Our western plains, especially in the warmer regions, abound in similar beetles; they are found in large numbers beneath dry dung, and some of them are very peculiar beings, having their wing-covers soldered together, since they possess only rudimentary true wings or none at all. Fig. 181, (Plate I) shows a very peculiar insect, black and white in color; it is *Zopherus Haldemani* Salle.

One of the most peculiar beetles belonging to this family is frequently received by the entomologist as a great rarity, simply

because the males have a pair of enormously large horns on the pro-thorax. This beetle, (*Boletotherus bifurcus* Fab.), possesses a very rough surface on the body and wing-covers, and is of a dirty brownish color. It feeds upon the large toadstools, (*Polyporus*), so common on the sides of dead and dying trees. Fig. 182, Plate II, shows both sexes of this remarkable insect.

A large number of small families of beetles follow, but none of the insects contained in them are of any great economic importance.

FAMILY MORDELLIDAE.

The beetles in this family are all small, some very small. Some are black, others are variegated, but all are covered with a silky pubescence. Such beetles are found in immense numbers during the early summer, in many kinds of flowers, in which they feed upon the pollen. In doing so they are of some importance in cross-fertilization.

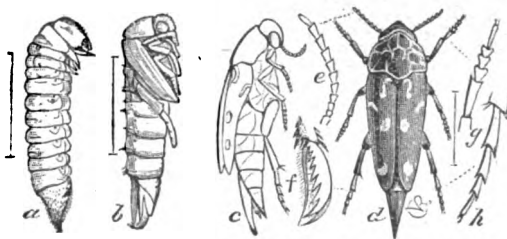


Fig. 183.—*Mordella 8-punctata*, Fab.—After Riley.

As may be seen in the illustration, (Fig. 183), which shows *Mordella 8-punctata* Fab., they have a very arched body, the head is bent down, and the abdomen is usually prolonged into a slender point. They are very active, flying readily, but they usually try to escape by the most intricate contortions, which make it almost impossible to secure them, and they usually drop to the ground and are lost. Their larvæ live in rotten wood and in the pith of plants.

(*Blister-beetles*).

Perhaps the most interesting and economically the most important among the *Heteromera* are the "Blister-beetles," which have received this very appropriate name because they can raise blisters on the human skin, caused by a substance "cantharidin" found to a greater or less extent in nearly all members of this family. To utilize them for this purpose they are dried and pulverized, and the powder thus obtained is made into a paste, which applied to the skin by physicians causes local inflammation and a blister. Nearly all our common species can be utilized for this purpose, but the kinds generally used come from Spain and other European countries, hence are called "Spanish-fly," (Fig. 184).



Fig. 184.—Spanish flies. After Brehm.

All the beetles belonging here are soft-bodied and of medium or large size; their head is broad, vertical, abruptly narrowed into a neck; the pro-thorax is narrow and cylindrical, and is narrower than the wing-covers, which extend well down the sides; the legs are long and slender, and the feelers are in some cases knotted in the males. Many of the species are brightly colored and banded, some are metallic bronze or copper, others are uniformly gray, black or brown, with black longitudinal stripes. All are leaf-feeders and are found in flowers.

One of our most common species is black, and occurs in large numbers on the flowers of the golden rod. A number of species of this family are very destructive to the leaves of the potato, bean, aster, rose and other plants, and one at least is decidedly injurious to the flowers of the cultivated shad-berry. This large beetle, (*Pomphopoea aenea* Say), called the *Pear-tree Blister-beetle*, is also fond of the leaves of apples. (Fig. 185).

The metamorphoses of blister-beetles are remarkable, as they do not alone undergo wonderful changes in form, but the number of such changes is greater than usual with beetles. The adult deposits a large number of yellowish eggs in the ground, which hatch into very active long-legged larvæ, that run about in search of food consisting of the eggs of locusts and of some solitary bees. Eating the eggs of locusts is a very good habit, hence the blister-beetles are decidedly beneficial in their larval stage, and it is a well known fact that in a year following locust troubles blister-beetles become very numerous. In other cases the eggs are either laid on a plant or on the ground, and similar long-legged larvæ are hatched, which run about the flowers until a proper kind of bee comes along, to the hairy clothing of which they fasten themselves, and in this way are carried to the nest of the bee, not simply stealing the ride, however, but adding injury to insult, for after quitting the unsuspecting host it devours the egg or young larva and later completes its own transformation, meanwhile feeding upon the accumulated stores, the rightful owner of which it has killed.

These young larvæ of blister-beetles are active little creatures, with long legs, prominent jaws, large heads, and are known as "triungulins."

The most common of our blister-beetles are the uniformly gray *Macrobasis unicolor* Kirby. (Fig. 151, Plate II), and the black *Epicauta pennsylvanica* DeG. As a description of both is given in the first annual report it is not necessary to repeat it here.

If these insects, as well as similar ones, should become very destructive, they can be killed by a thorough application of one of the arsenites, adding some milk of lime to make the poison

stick, and this should be carried into effect as soon as they are noticed. In some cases they can also be driven to a layer of straw, which is then burned. But as the larvæ feed upon such dangerous material as the eggs of locusts, it is in many cases better not to kill the adults.

Of the larger and brighter species one of the most common is a rather beautiful beetle, the *Cantharis Nuttalli* Say; it measures over an inch in length, has dark, purplish or bluish-green



Fig. 185.—*Pomphopoea ænea*, Fig. 186.—*Meloe angusticollis*, Say. After Saunders. Fig. 187.—Head of Snout-beetle; *g. s.*, gular suture. Harris.

wing-covers, and a metallic green thorax, head and abdomen. It is sometimes very common in our prairies, where it destroys wild roses and other flowers. It resembles the genuine Spanish fly very closely, and should be gathered and sold to the manufacturing chemists.

The OIL-BEETLES (*Meloe* species), are also included, but they are not numerous enough to cause any damage. Our common species, the *Meloe angusticollis* Say, is shown in Fig. 186.

II. SUB-ORDER RHYNCHOPHORA.

SNOUT-BEETLES; BARK-BEETLES.

This sub-order includes beetles commonly called *Snout-beetles* and *Bark-beetles*, ten families of which are represented in North America. The great peculiarity of these insects is found in the head, which is more or less prolonged into a *beak* or *snout*, sometimes longer than the remainder of the body, but usually

shorter. It is either broad or thin, short or long, straight or curved. The small sharp jaws are situated at the end of the beak or *rostrum*; the labrum and palpi are small or wanting; the slender feelers arise from the sides of the beak, and are elbowed in the middle, ending in a knob or club; the *rostrum* is often grooved at the sides for the reception of the feelers, and the eyes are small and round. But the most distinctive character is the absence of the gula, there being but a single gular suture, (Fig. 187), and the epimera of the pro-thorax meet on the middle line behind the prosternum. The body is compact, and frequently wedge-shaped, and not uncommonly has a ridged and pitted surface, or is raised into tubercles. The tarsi are four-jointed, each joint strongly bilobed and cushioned beneath. None of our species are of more than medium size, and most of them are very small.

Nearly all our northern species of snout-beetles, when disturbed, feign death, and do so most skillfully and persistently; the feelers disappear into the grooves in the beak, and the latter is bent under in many cases, close to the body, as are also the legs, and the beetle drops to the ground, closely resembling a bit of twig, a bud, or a seed, and thus escapes detection. In the tropics, however, many of such beetles are very active, and take to their wings almost as readily and easily as the tiger-beetles.

Many of the larvæ of such insects live in fruit, seeds, nuts; others devour the substance inside the stems of plants, and still others subsist on wood. Larvæ of snout-beetles are usually more or less curved, pale, and much wrinkled, as may be seen in the following illustrations, which show their structure as well as that of the adults and pupæ.

FAMILY RHYNCHITIDÆ.

This family includes small beetles in which the elytral fold is very feeble, the labrum wanting, and in which the mandibles are toothed both on the outer and inner side. The mandibles can be widely spread apart; when closed the outer tooth at the end

of each projects forward, so that two small and acute teeth seem to project.

We have a number of such small beetles in our state, one, of which, of a dark blue-black color, covered with fine and dark hairs, is rather common in various flowers early in the season. Another species, (*Rhynchites bicolor* Fab.), is polished red above, excepting the snout, legs, and under side, which are black, and is sometimes very common and destructive to our roses. It destroys both flower buds and flowers, and deposits eggs into the fruit, in which the young mature. Both wild and cultivated flowers are thus invaded, but especially the former. The beetle measures about one-fourth of an inch in length, not including the long snout which is about as long as the abdomen.

FAMILY ATTELABIDAE.

(*Leaf-rolling Snout-beetles*).

Such beetles have neither an elytral fold nor a labrum; the mandibles are flat, pincer-shaped, and toothed on the inner side. They are mainly interesting from the fact that the females make a compact thimble-shaped roll from leaves, in which a single egg is deposited, and inside of which the larva feeds until full grown, when it leaves and enters the ground for pupation. It is very interesting to see the female at work making such a cradle for its young, and as at least two species are fairly abundant in our state the lover of nature will have but little trouble to observe the whole operation. One species, polished black, with a large dark-red humeral spot, occurs upon our oaks; it is *Attelabus bipustulatus* Fab. The other species, *A. rhois* Boh., occurs upon the hazel and alder; it is brown and densely covered with yellowish-white hairs. The illustration, (Fig. 189), shows a thimble-shaped cradle on oak, and Fig. 188, the adult of *A. analis* Ill.

Prof. Packard describes the operation of making such a cradle as follows: "When about to lay her eggs the female begins to eat a slit near the base of the leaf on each side of the midrib, and at right angles to it, so that the leaf may be folded together.

Before beginning to roll up the leaf she gnaws the stem nearly off, so that after the roll is made, and has dried for perhaps a day, it is easily detached by the wind and falls to the ground. When folding the leaf she rolls it up tightly, neatly tucking in the ends until a compact, cylindrical, solid mass of vegetation is formed. Before the leaf is entirely rolled she deposits a single egg, rarely two, in the middle next to the midrib, where it lies loosely in a little cavity. While all this is going on her consort stands near by, and she occasionally runs to him to receive his caresses, then again resumes her work. These rolls sometimes remain on the bushes for several days, but probably drop by

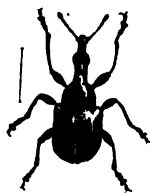


Fig. 188.—*Attelabus analis*, III.



Fig. 189.—Thimble-shaped cradles on oak.

the time the larva escapes from the egg, and it seems probable that the grub uses the roll for a shelter until it matures and is ready to enter into its transformations into a beetle." In Minnesota the writer has frequently seen the female at work, but invariably she worked alone, no male being near. In many cases the larva also changes to a pupa inside the cradle, and the latter to a beetle, without entering the ground at all. Evidently love does not always run as smooth here as in the east!

FAMILY OTIORHYNCHIDAE.

(Scarred Snout-beetles).

This family contains a large number of snout-beetles. Their most distinguished characteristic is the presence in the pupal state, and sometimes also in recently matured adults, of an appendage on each mandible, and in the adult state a scar indicates the place from which the appendage has fallen. This scar is on the anterior face of the mandible, and frequently at the tip of a slight process. (Comstock).

Most of our species are more or less ornamented with scales resembling those found upon the wings of butterflies. This is very prominent in tropical species, where such scales are frequently of metallic colors, and are exceedingly beautiful, and on that account are utilized by microscopists for forming baskets filled with flowers of different shapes and colors; such baskets are so minute as to become plainly visible only under a strong lens.

Among the beetles forming this family we possess several species which are more or less injurious to fruit-producing plants.

THE IMBRICATED SNOOT-BEETLE.

(Epicaerus imbricatus Say).

This rather omnivorous beetle, gnawing holes in various garden vegetables, is also found on the apple and cherry, injuring them by eating holes in the twigs and fruit. It is by no means common in our state, but destructive in others, hence requires the attention of our fruit-growers. It is a very variable beetle, but usually of a dull silvery-white color, with darker markings; sometimes two light-colored bands extend across the elytra, which are striated with longitudinal rows of deep round pits. This beetle can readily be recognized by the peculiar shape of the posterior end of the elytra, which is very steep, cut off almost squarely, and ends in a sharp and pointed elongation. If it should ever become more numerous than it now is, it can be kept in check

by jarring the trees, as is done in the case of the plum-curculio described later. The illustration (Fig. 191), shows both shape and size of this beetle and that of the egg and larva.

Mr. Chittenden describes the life-history in one of the admirable bulletins of the Division of Entomology, issued by the Department of Agriculture. He writes that these beetles are sometimes very destructive to strawberry plants, eating the leaves,

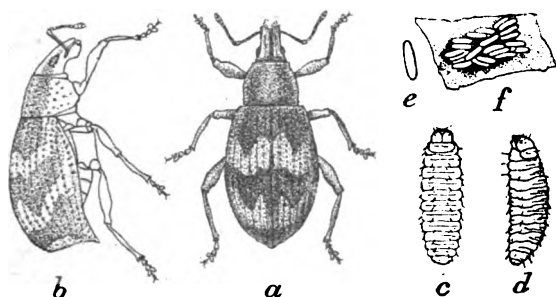


Fig. 191.—*Epicærus imbricatus*, Say.—Division of Entomology, U. S. Department of Agriculture.

and later the entire stem. "The eggs are elongate, more than three times as long as wide, somewhat variable in outline owing to close deposition, sub-cylindrical, sometimes slightly curved on one side, broadly rounded at each end, surface smooth, shining without any apparent sculpture; color light dull yellow." The young larva, when first hatched, is uniform whitish-yellow.

THE GRAY ANAMETIS.

(*Anametis grisea* Horn).

This is another beetle, (Fig. 192, Plate II), last season discovered for the first time in our orchards to be injurious to the apple, in the leaves of which it eats large holes; it likewise eats the tender bark of the same tree. It has the peculiar habit of hiding in the folds of a leaf during the day, on the underside, and is here difficult to detect, as its silvery white color blends well with the white down of the leaves. It is easily beaten into an in-

verted umbrella, and if numerous could be captured very readily. It is a robust insect, about the size of the imbricated snout-beetle, of a brownish-gray color. It is not often seen, but by beating apple trees, as suggested above, it will be found to be much more common than was suspected.

Cercopeus chrysorhoeus Say, a similar beetle, is from time to time found on the foliage of the grape, and a number of others occur, but very rarely, upon the flowers and foliage of some of our fruit-producing plants, but none cause any extensive damage.

THE PITCHY-LEGGED OTIORHYNCHUS.

(*Otiorhynchus ovatus* Linn.).

This beetle, a typical one of the family, is getting very numerous, and may, in time, cause injuries to the roots and crowns of straw-berries. It has also been reported as feeding upon the leaves of the apple. Here at the Experiment Station it was not found until four years ago, but now is very abundant, especially very early in spring, just after the snow has disappeared, and again late in autumn. At such times it is found resting on the sides of houses, not far from the ground. In autumn it is ready to enter the ground to hibernate, and in spring it leaves such quarters to enjoy the warmth of the sun. But what attracts such large numbers of beetles to houses is difficult to understand, especially as these buildings are surrounded by well kept lawns. Usually they can be found hibernating among logs and pieces of bark lying upon the ground.

No damages have been observed, but a number of the crowns and roots of strawberries received from other parts of the state tell a sad story, as they were excavated and killed by the larvæ of this beetle. They are much more destructive than the strawberry root-borer, which will be described later.

The beetle, illustrated in Fig. 193, is very dark-brown, almost black; the thorax is very deeply pitted, the pits being sometimes arranged in more or less regular rows; the wing-covers are striated, and at regular intervals in the striæ are deep punctures.

The insect is very convex; the thorax has a projecting angle at each side, and the body is almost egg-shaped.

Judging from the work seen such snout-beetles can become very destructive, and it will be difficult to combat them. Many years ago a snout-beetle infesting the roots of grasses was very numerous in Druid Hill Park, Baltimore, Md., yet its presence was not suspected at all, as no injury to the lawns was noticed, except that the plants seemed to need food, which was provided them in the form of a very bad-smelling manure obtained from cleaning hog-bristles imported from Hungary for the manufacture of brushes, etc. A liberal application of this substance was



Fig. 193.—*Otiorhynchus ovatus*, Linn.

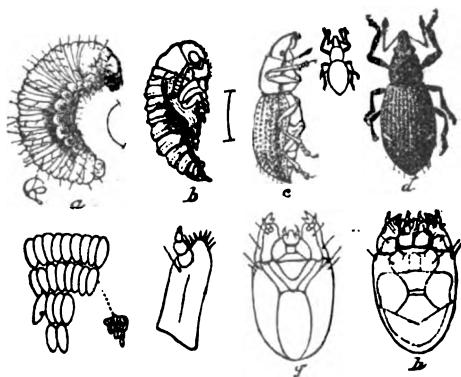


Fig. 194.—*Aramiges Fulleri*, Horn. After Division of Entomology, U. S. Department of Agriculture.

spread over the lawns, and was followed by a heavy rain. Next day immense numbers of beetles (*Sphenophorus parvulus* Gyll.) could be seen upon all the sidewalks and seats on and about the lawn; they were evidently driven out of the ground by this offensive manure. Perhaps this experience might show us a method by which we could combat this and similar insects.

Two other species of the genus *Otiorhynchus* (*O. sulcatus* Fab., and *O. picipes* Fab.), as well as *Thricolepis simulator* Horn, are known to injure the apple elsewhere.

FULLER'S ROSE-BEETLE.

(Aramiges Fulleri Horn).

Some years ago this insect, (Fig. 194), became very injurious in the east in some green-houses devoted to roses. It is an oval, dark, smoky-brown snout-beetle, lightly covered with scales, with a short and obtuse snout; it is about one-fourth of an inch in length. The eggs are laid in masses under any sort of shelter on rose-bushes, and the white and grub-like larvæ hatching from them feed on the tender roots of roses, while the adults destroy leaves, flowers and buds. The attacks of the larvæ weaken the plants, or kill them outright.

Since the long-lived beetles hide during the day on the under-side of the leaves they can be collected and destroyed; the free use of a tobacco extract on the ground will act both as a fertilizer and as a destroyer of the subterranean grubs. The same beetle is sometimes a pest in the orange groves of California, and is replaced by another similar one in those of Florida.

A number of other similar beetles might be mentioned as being sometimes injurious to our fruit-producing plants, but as they are very uncommon in Minnesota, it is not necessary, as all can be destroyed by the remedies already given.

FAMILY CURCULIONIDÆ.

(Genuine Snout-beetles).

The family *Curculionidæ* is the most important of the families of snout-beetles, including more than one-half of all the insects of this character found in the United States, and a large number of them are most destructive insects. In this family there is a strong fold on the lower side of each wing-cover near the outer margin, which limits a deep groove into which the upper edge of the abdomen fits; the mandibles have no scar; the antennæ are usually elbowed, and have a ringed or solid club; the tarsi are usually dilated, with the third segment bi-lobed and spongy beneath; in a few cases the tarsi are narrow, but not spinose beneath. (Comstock).

The soft and white larvæ possess no feet, and feed chiefly on fruits, seeds and nuts, but all parts of plants are subject to their attacks.

The female bores a hole with her snout, and deposits an egg in the hole thus formed, pushing the egg to the bottom of it with her beak. For this purpose the snout of a female beetle is very long, sometimes longer than the remainder of the body, as may be seen in the acorn weevil illustrated later.

Although not injurious to fruit-producing plants there are a number of small snout-beetles which are so frequently sent to the entomologist as being injurious to the roots of grasses, that a few words about them may not be out of place. The species of *Sitones*, of which a number occur in our state, are all small, blackish-gray, covered with very minute scales, and in some cases marked with a number of darker spots, interrupted by white, arranged in regular longitudinal rows. Some species are illustrated in Fig. 195.

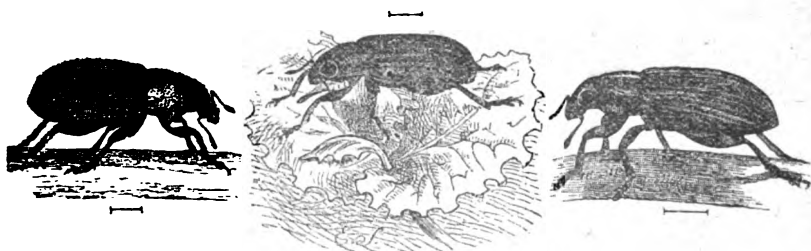


Fig. 195.—*Sitones* species. After Brehm.

THE NEW YORK WEEVIL.

(*Ithycerus noveboracensis* Forster).

This is about the largest snout-beetle we have in our state; it is not only the largest, however, but also sometimes exceedingly destructive, especially so in early spring, when plum trees growing near oak forests are badly injured. In such cases the beetles congregate upon plum and other fruit trees in May or early June, eating the buds and gnawing into the twigs, chiefly at their base,

thus causing them to break and fall. The younger bark of twigs is used as food and numerous holes are eaten into it; the tender shoots are entirely devoured, and later they eat the leaves just at their base. The beetle is shown in Fig. 196; it is from four to six-tenths of an inch in length, of an ash-gray color, marked with black; four whitish lines, interrupted by black dots, are on each of its wing-covers, and three smaller ones occur on the thorax. The scutellum, located at the juncture of the elytra with the thorax, is yellowish. Such beetles frequently occur in swarms in nurseries, where they cause serious injury to the apple, plum, cherry, pear, peach and other trees. Fig 196, Plate VI, shows their work.

It is quite abundant in the wooded regions of Minnesota, but is not seen as often as their numbers would warrant, simply because it is a nocturnal insect, hiding in the cracks of bark of oak trees during the day, and in such places it is almost impossible to detect it, as it resembles the bark very closely in color and in markings.

The larva, also shown in the illustration, is found in the twigs and tender branches of the burr-oak, and also in the hickory. According to Saunders, when the female is about to deposit an egg, she makes a longitudinal excavation with her jaws, as shown

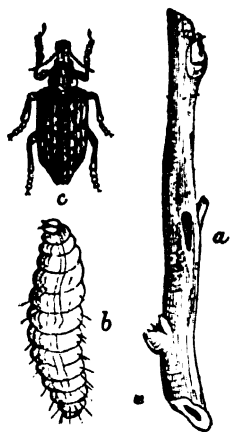


Fig. 196.—*Ithycerus novoboraceus*, Forst.—After Riley.



Fig. 197.—*Apion* species.—After Brehm.

at *a* in the illustration, eating upwards under the bark; afterwards she turns round and places an egg in the opening. The larva, *b*, is a soft, foot-less grub, of a pale-yellow color, with a tawny head.

There is but one safe way to destroy this beetle; it has to be caught by jarring, the same way as our plum-curculio, since it also has the habit of dropping to the ground when alarmed, as most other snout-beetles do. Paris-green and London-purple, applied in such a way as to make them stick to the tender twigs and branches, will also kill large numbers of this mischief maker.

There is a group of small beetles, (*Apion*), the larvæ of which usually feed in the seeds of plants, as in those of the false indigo, (*Baptisia tinctoria*), the seeds of the locust, and others. To show how these beetles look one has been illustrated, and well shows their peculiar form (Fig. 197). They are equipped with a long and slender projecting beak, have straight feelers, and

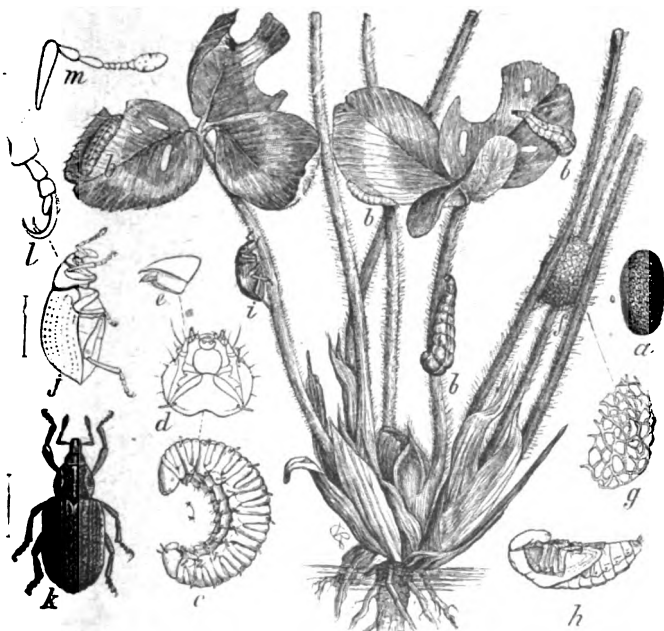


Fig. 198.—*Phytonomus punctatus*, Fab.—After Division of Entomology, U. S. Department of Agriculture.

are very small, the largest not measuring much more than one-tenth of an inch, including the beak. Their colors are black, grayish, dark blue, or even greenish; only a few in the United States are of a brighter color, such as reddish or yellowish.

This is a good place to mention another bad snout-beetle, not yet found in Minnesota, but which is working its way in the direction of our state. It is the *Clover Leaf-beetle* (*Phytonomus punctatus* Fab.). It is a large beetle, dull brown in color, with indefinitely striped elytra, and a short, stout beak. Prof. Smith says about it:

"The larva is green, its form is well shown in the figure, (Fig. 198), and it feeds chiefly at night, eating irregular holes into the leaves. When full-grown it forms a peculiar net-like cocoon, at or a little beneath the surface of the ground, and pupates, becoming adult a few days thereafter. The insects hibernate in the larval stage, and their injury becomes manifest quite early in the season, often threatening entire destruction of the crop when they are full-grown. Fortunately nature has provided a check for this insect in a fungous disease, which in most localities carries off the larvæ annually, just before they mature, leaving only a comparatively small proportion to perpetuate the species. As this disease seems to occur in seasons of all kinds, and irrespective of climatic conditions, it can be easily introduced into any locality in which the insects become destructive. Affected larvæ (Fig. 199), curl themselves round a spear of grass, or on the edge of a leaf, and die, first swelling somewhat and becoming gray in

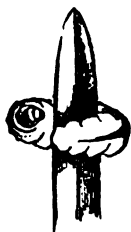


Fig. 199.—*Phytonomus* killed by disease. After Division of Entomology, U. S. Department of Agriculture.



Fig. 200.—*Pissodes strobi*, Peck.—After Division of Entomology, U. S. Department of Agriculture.

color; then they collapse and become black, eventually forming a small, dried, black mass, utterly indistinguishable in character."

We have a number of very noxious snout-beetles which kill our pine trees. Only one will be mentioned and illustrated, (Fig. 200), to show its shape. It is the *White Pine Weevil*, (*Pissodes strobi* Peck). It is one of the most serious enemies to that tree, attacking the leading shoots in young trees, and spoiling their shape entirely. In our extensive pine forests no remedy can even be suggested, but in parks and gardens the small ornamental trees of this kind can be protected to some extent by spraying the



Fig. 201.—European species of *Pissodes*. After Brehm.



Fig. 202.—*Hylobius confusus*, Kby.—After Brehm.

leading shoots with carbolated soap-wash, to which Paris-green is added at the rate of one pound to one hundred and fifty gallons of water (Smith). Of course the infested shoots should be gathered and burned. Fig. 201 shows a closely related European species.

Equally bad are *Pissodes affinis* Rand., and *Hylobius confusus* Kby. (Fig. 202).

Another group of snout-beetles is composed of very elongate and slender insects, some of which are injurious to garden plants, and on that account one of them is shown in the illustration (Fig. 203). It is the *Rhubarb-beetle*, (*Lixus concausus* Say). This beetle is found early in the season on the leaves and stems of the rhubarb, but is also found on those of wild plants, as on the larger species of *Rumex*. This long, cylindrical beetle, with a thick snout about as long as the head and thorax, is entirely covered with a rusty powder, which rubs off very easily,

and exposes the dark slate-colored body, which is remarkable for its exceedingly firm texture. In fact this insect is so hard that a common insect pin will not perforate it. The beetle bores little holes into the leaf and flower stems of the plant, depositing one egg in each, from which a white, grub-like larva hatches, which devours the plant tissue. The insect is not common in Minnesota. According to Smith, Webster and others, whenever the leaves are regularly cut for the market but little trouble is experienced; old leaves should be removed and destroyed, so that

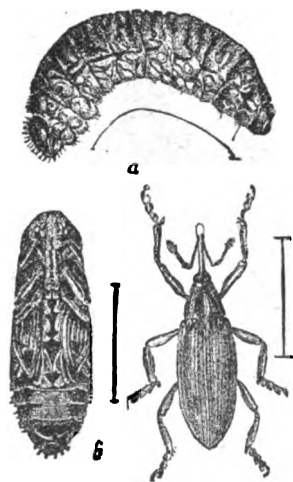


Fig. 203.—*Lixus concavus*, Say. After Webster.



Fig. 204.—*Lixus* from Europe. After Brehm.

none of them remain after midsummer. Several species of *Lixus* occur in our state; a European species found in aquatic plants is shown in Fig. 204.

Among the large number of snout-beetles that follow the above genus in the classification but few are really injurious, although they occur in the flowers of such plants as the strawberries, blackberries, raspberries, and others. Perhaps two species of *Magdalis* are an exception, as the one (*M. aenescens* Lec.) is frequently found upon the apple-tree, and the other (*M. olyra* Hbst.)

has the bad habit of tunneling, in the larval state, into the bark of hickory in every direction, leaving only just enough tissue to prevent the bark from warping away from the tree. Mr. Bowditch states that, "as far as my observations extend, the species appears to prefer small trees, from four to six inches in diameter. If the tree is small and very badly infested it dies very quickly, and shortly after the beetles have escaped, the bark is apt to flake

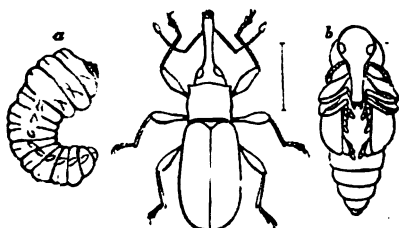


Fig. 205.—*Magdalis olyra*, Herbst. a. larva; b, pupa. After Packard.



Fig. 206.—*Magdalis armicollis*, Say. After Forbes.

off and curl up in quite large pieces." As a general rule, however, this beetle prefers the red oaks. Fig. 205 shows *M. olyra* Herbst, found abundantly boring under the bark of oak, and Fig. 206 *M. armicollis* Say.

THE PLUM GOUGER.

(*Coccotorus scutellaris* Lec.).

This destructive beetle has been described in the "Second Annual Report of the Entomologist," but to make this report on beetles injurious to fruit-producing plants more complete, it is repeated.

There is no kind of fruit that promises so well in Minnesota as the plum, and wonderful progress has already been made in the past to improve our wild species, and to create, by selection, crosses, or by other means, new and better varieties, and it seems, when we look at the samples of plums shown last year at the different fairs, that before very long fruit superior to all other growing now will be the result of such painstaking work. It seems to the writer that the only true road to success has been chosen, viz.:

to improve the native kinds, which are known to be hardy, and not to attempt to bring to our state others found in countries differing in climate from ours. We have, in improving our native plums, to follow the same steps that were taken in the past in Europe to change their native crab-apples into the beautiful, delicate varieties of apples now grown everywhere. But to grow plum trees and to harvest plums are two quite distinct things. A little observation will almost convince the horticulturist that he is growing the plums not for his own use, but for that of his enemies. He sees that after a plum orchard is once established these have taken possession of the same and seem to consider it their own. There are few plants in Minnesota that have more enemies than the plum-tree: black knot, plum pocket, powdery mildew, brown rot, plum leaf-blight, plum-rust, leaf-spot or gun-shot and others are a few of the more important vegetable foes of this tree, while plant-lice, such as the plum tree aphis, the plum gall-mite, many caterpillars, the plum-gouger, and the plum-curculio, are the more destructive insect enemies.

The plum-gouger, (Fig. 207, Plate V), is the most destructive of the above named insects in Minnesota. It is a reddish-brown snout-beetle, with a peculiar pruinose, almost velvety surface, and is of a very different shape from the better known but less common plum-curculio. In the spring of 1896 the plum trees on and near the Experiment Farm were in full bloom and promised rich returns. But before long one flower after another dropped off, and but comparatively few were left upon the trees, and in some cases none remained. When the cause of this trouble was investigated it was found that this snout-beetle was busily engaged in gouging holes in the flower (see Fig. 207, Plate V), which, in consequence, shrivelled and dropped. A rather suicidal way of doing things, for by acting in this manner the beetles actually destroyed their future food and home! As the fruit grows, the female beetle, in depositing an egg, does not form the crescent-shaped mark of the "Little Turk," but makes for this purpose a small and deep puncture. Prof. Bruner describes the egg-laying habit of the plum-gouger as follows: "The modus

operandi is very simple, and requires but a minute and a half to two minutes for the performance of the entire operation. She first spreads out her legs to their full extent, braces them, and then draws her beak or rostrum to as nearly a perpendicular position as possible, then by gnawing, and with a twisting motion she soon works her snout into the fruit until it is buried a trifle above the bases of the antennæ, the latter being held close against and directed upward along the rostrum upon the head while the hole is being made. She now draws out her beak, and deliberately turns about, and after a few preliminary thrusts of the ovipositor inserts the latter into the hole just made with the beak, and deposits a single egg that is of the diameter of the puncture. The egg is of a dirty whitish, somewhat transparent color, and is plainly visible with an ordinary pocket lens, being uncovered and nearly flush with the surface. It soon becomes covered by a healing of the injured fruit." Each female deposits only one egg in a young plum; if more are found it is the work of different females. The larva that hatches from such an egg is never exposed, hence can not be killed by sprays with arsenical poisons. In entering the fruit a transparent or gummy substance collects over the puncture, as is well shown in the illustration. The larva feeds not only upon the flesh of the plum, but upon the flesh of the kernel inside of the stone. Here it undergoes its transformation from a larva to a pupa and to the adult insect, which later leaves as soon as strong enough to do so, and searches for hibernating quarters in and about the orchard. Many of the plums that contain the worms drop, and should be removed and destroyed, but many others remain on the trees long after the beetles have left, and some of them are even still fit for culinary purposes. There is very little use in spraying. Jarring early in the season, at the time the trees are in full bloom, or even a little sooner, will bring down many of these injurious beetles, and if this is done early in the morning they can be readily gathered and killed. The jarring has to be done in a forcible manner, as the beetles cling very tightly to the tree.

Another species so closely resembling the above species as

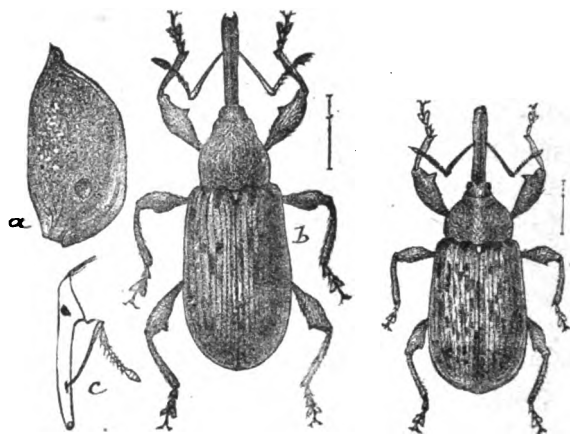


Fig. 208.—*Coccotorus scutellaris*, Lec. and *C. prunicida*, Walsh.—After Division of Entomology, U. S. Department of Agriculture.

to be almost indistinguishable, is found upon the sand-cherry. It has similar life-habits. Both are shown in Fig. 208, and it will be seen that the difference between them is but slight.

In the genus *Anthonomus* we possess a large number of beetles, all small, with modest colors, but with great power of injury. Only a few of the more important ones will be given.

THE APPLE CURCULIO.

(*Anthonomus quadrigibbus* Say).

This is a common beetle in Minnesota, where it is found breeding almost exclusively in wild crabs and haws, but it is simply a question of time when it will also attack the cultivated apple, which it does in states having older orchards. Prof. Saunders gives the following description of this insect:

"It is a small beetle, a little smaller than a plum-curculio, of a dull brown color, having a long, thin snout, which sticks out more or less horizontally, and can not be folded under the body, as is the case with many species of curculio. This snout in the female is as long as the body; in the male it is about half that length. In addition to the prominent snout, it is furnished with

four conspicuous brownish-red humps towards the hinder part of its body, from which it takes its specific name, *quadriggibus*. Including the snout, its length is a quarter of an inch or more. In the accompanying illustration (Fig. 209), the insect is magnified; *a* represents a back view, *b* a side view; the outline at the left shows its natural size. Its body is dull brown, shaded with rusty red; the thorax and anterior third of the wing-covers are grayish.

"This is a native American insect which formerly bred exclusively in the wild crabs and haws; it is single-brooded, and passes the winter in the beetle state. The beetle appears quite early,

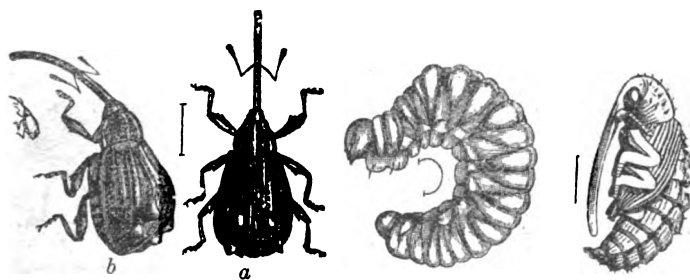


Fig. 209.—*Anthrenus quadriggibus*, Say. After Riley.

and the larva may often be found hatched before the middle of June, and in various stages of its growth in the fruit during June, July, and August.

"The beetle with its long snout drills holes into the young apples, much like the puncture of a hot needle, the hole being round, and surrounded by a blackish margin. Those which are drilled by the insect when feeding are about one-tenth of an inch deep, and scooped out broadly at the bottom; those which the female makes for her eggs are scooped out still more broadly, and the egg is placed at the bottom. The egg is of a yellowish color, and in shape a long oval, being about one-twenty-fifth of an inch in length and not quite half that in width. As soon as the larva hatches, it burrows to the heart of the fruit, where it feeds around the core, which becomes partly filled with rusty-red excrement.

In about a month it attains its full size, when it presents the appearance shown in Fig 209, which represents the larva and the pupa highly magnified. Fig. 210 shows an infested apple, the egg *c*, and egg-cavity *b*.

"The larva is a soft white grub, nearly half an inch in length, with a yellowish-brown head and jaws. Its body is much wrinkled, the spaces between the folds being of a bluish-black color; there is also a line of a bluish shade down the back. Having no legs, it is incapable of much movement, and remains within the fruit it occupies, changing there to a pupa of a whitish color, and in two or three weeks, when perfected, the beetle cuts a hole through the fruit and escapes.

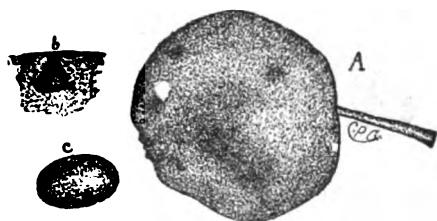


Fig. 210.—Apple containing eggs; *b*, egg-cavity, natural size; *c*, egg, much enlarged. After Gillette.



Fig. 211.—*Anthonomus signatus*. Say. After Division of Entomology. U. S. Department of Agriculture.

"When feeding this insect makes a number of holes or punctures, and around these a hard knot or swelling forms, which much disfigures the fruit; pears, as well as apples, are injured in this way. The infested fruits do not usually fall to the ground, as do apples affected by the codling worm, but remain attached to the tree, and the insect, from its habit of living within the fruit through all its stages, is a difficult one to destroy. Picking the affected specimens from the tree, and vigorously jarring the tree during the time when the beetle is about, will bring it to the ground, where it can be destroyed in the same manner as recommended for the plum curculio. Fortunately it is seldom found in such abundance as to do much damage to the fruit-crop. In Southern Illinois, and in some portions of Missouri it has proved

destructive, but in most of the Northern United States, and in Canada, although common on thorn-bushes and crab-apples, it seldom attacks the more valuable fruits to any considerable extent."

THE CRANBERRY CURCULIO.

(*Anthonomus suturalis* Lec.).

About the middle of July we can find numerous beetles of this kind in the blossoms of this plant, but they are also found upon many other kinds. The small beetle is very variable in color, but is usually reddish-brown, with a dark brown head, and a beak about half as long as its body. The pro-thorax is darker than the elytra, and is covered with short, whitish hairs; the elytra are ornamented with rows of indented dots, and are in most cases black along the suture, which color sometimes forms a triangular spot in the middle, of which the whitish scutellum is the center. The beetle measures a little over one-eighth of an inch in length, including the rather long beak. When the female has selected the bud of a blossom she drills, with the snout, a hole through the center, and in this hole she deposits a pale yellow egg. This done, she cuts off the flower stem, which drops to the ground; the egg hatches a dull white grub with a yellow head armed with black jaws with which it devours the inside of a bud, eventually eating its way out, leaving a round hole in the side of the bud, and transforms to a pupa, and soon afterwards to a perfect beetle, which may sometimes be seen feeding upon the berries.

The only remedy in such a case is to flood the cranberry swamp, which will drown the larvæ and pupæ.

THE STRAWBERRY CURCULIO.

(*Anthonomus signatus* Say).

This is one of the most troublesome of the strawberry insects, but as yet is found only in very limited numbers in our state, preferring here to feed in the blossoms of the wild plants. Its history is well known, and the writer had the doubtful pleasure of first observing its actions while assistant of Prof. Riley in Mis-

souri. Prof. Smith writes that it "appears as a small, blackish beetle, with gray pubescence, when the buds are developing, and lays an egg into each, afterwards puncturing the flower-stalk below the bud so as to check further development. The larva feeds upon the pollen in the unopened bud which affords sufficient food till it attains its full growth, changing to a beetle in midsummer. The insect attacks a number of other flowers in the same way, not even confining itself to one natural family, and its injury to strawberries is of a somewhat intermittent character, becoming worse for a number of years, then stopping suddenly for no apparent reason. Only staminate or pollen-bearing varieties are attacked, and the Sharpless is perhaps the most seriously infested. By planting chiefly pistillate varieties the staminate rows may be protected by cheap coverings until the buds are ready to open, and even if only a small crop is obtained on the pollenizers, the main crop will be safe without protection. Insecticides have not proved markedly useful in this case." This species is shown in Figs 211 and 212.

Many other species of the genus *Anthonomus* are found in the flowers of apple, crab, and thorn, and may be more or less injurious; such are *A. profundus* Lec., *A. decipiens* Lec., and *A. crataegi* Walsh, the latter being often very numerous in the flowers of the crab-apples.

Another species of these destructive snout-beetles has of late become very destructive in our cotton growing states, into which it found its way from Mexico. It is *A. grandis*, famous or rather infamous on account of its bad habit of eating into the bolls of cotton, which it destroys.

In Europe many species of this genus attack the flowers of the apple and plum, and are assisted in doing so by other beetles belonging to the genus *Rhynchites* already mentioned. The writer, in watching the English sparrows in the Eastern States, has frequently wondered why these birds should go to the trouble of picking such flowers to pieces, and especially those of the peach. They are so intent upon this work that not infrequently the great majority of the flowers are destroyed, and form a white

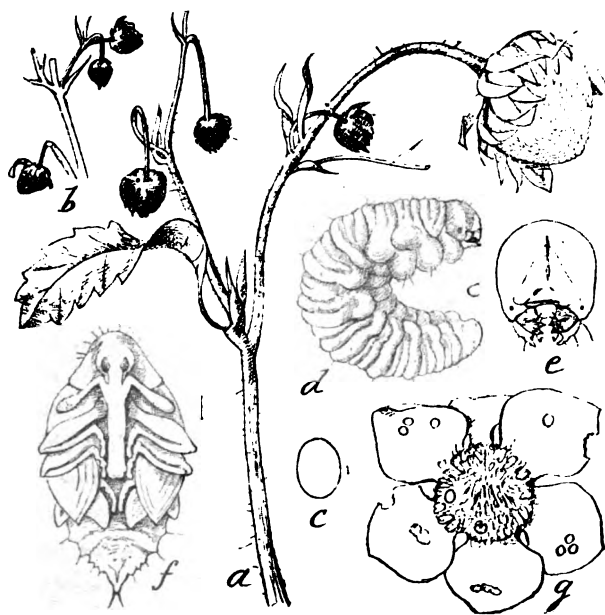


Fig. 212.—*Anthonomus signatus*, Say. Eggs, larva, pupa and injuries. After Division of Entomology, U. S. Department of Agriculture.

sheet beneath the tree. This action of the sparrows can not be done simply out of sheer mischief, but must have another cause. As these birds also pick into similar flowers in Europe to find beetles in them, there can be but little doubt that this habit of investigating flowers is so persistent that even here, after many generations of sparrows have died, their off-spring still possess it, and prompted by it search for insects not found here at all.

The next genus, *Conotrachelus*, also contains numerous destructive members, chief of which is the one described in the "First Annual Report," which is quoted:

THE PLUM CURCULIO.

(*Conotrachelus nenuphar* Hbst.).

We can hardly open an entomological bulletin issued by any of the eastern, central or southern states without finding a description of this insect, and of the remedies that will kill it and

save the fruit. Yet as a very general rule more is claimed for such proposed remedies than is warranted by facts, and many of the measures have not proved very satisfactory. This is especially true of the application of Paris-green and London-purple, which, with the Bordeaux mixture, are nowadays a sort of cure-all. All these substances are of great value, but as far as the "Little Turk" is concerned we have to depend for success very largely upon other methods, which, though requiring much more labor, are also much more certain. Though so well known, it is perhaps best to give an outline of the life-history of this insect, which is illustrated in Fig. 213, Plate III. As the illustration shows, this snout-beetle is less than one-fourth of an inch in length, is of a brown color with four sealingwax-like elevated excrescences on the hard wing-covers. The beetles hibernate among all sorts of rubbish, but prefer accumulated leaves and similar substances. Early in spring, and long before the buds of the plum-trees open, they visit the orchards, and eat the tender parts of the tree, such as green bark and buds; later they eat leaves, flowers and young fruit. Knowing this habit we can kill large numbers of the curculios by spraying the trees before the leaves and flowers appear. This should be done thoroughly, and as the foliage otherwise so very tender as regards arsenical substances is still enclosed, there is no danger of injuring the trees. When the flowers open we should not spray; it is more or less useless, and we run the risk of killing many honey-bees, which are attracted to them, and are very important, as without them but few fruits will set. As soon as the latter have reached the size of a small marble the female curculio commences to deposit her eggs: she makes a crescent-shaped cut and then separates and elevates a small flap into which the egg is inserted. This peculiar crescent-shaped slit has given the insect the name: "Little Turk"; it is made apparently to deaden the flesh of the fruit, or to delay its rapid growth, which otherwise might injure the enclosed delicate egg. This hatches in a few days, and the whitish larva or worm, also shown in the illustration, bores at once into the interior of the fruit until it reaches its stone, which it never enters, however.

as is the case with the plum-gouger, which always does so. The work of the larva is also shown. Though we can not poison the larvæ which are hidden inside the fruit, a second spraying about this time will do some good, as the females continue to deposit their eggs for a long time and require some food. As such spraying will also kill many other injurious insects of the plum-tree, it should not be neglected.

By midsummer the larva has reached its full size, and now leaves to pupate; it does so in the earth beneath the tree, and the pupa soon changes to an adult insect. As soon as able to move the freshly issued beetles search for hibernating quarters, and are not again seen in the orchard until the next spring.

As will be seen from the above account of the habits of this insect, it is not readily combatted by arsenical poisons, though two applications of them will do considerable good. Those who will apply either Paris-green or London-purple for this purpose should recollect that the foliage of the plum is very easily injured by all arsenical poisons, and that it is absolutely necessary to add at least equal parts of quick-lime which will neutralize all soluble arsenic and thus prevent injury.

The old remedy of jarring the trees every day or two over some sheets is after all the most successful one; in doing so during the day, when these beetles are not active, they drop very readily, and can be easily gathered and destroyed. The trees should be jarred, not simply shaken. It seems that by jarring we

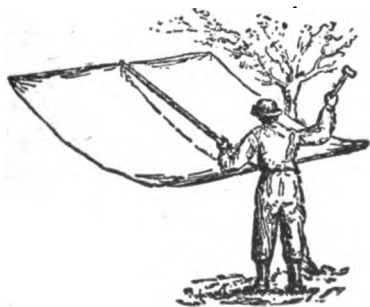


Fig. 214.—Machine to catch plum curculios. After Lintner.

imitate the vibrations produced by the hammering of wood-peckers, and the curculios drop to escape them, while shaking simply imitates the motion produced by the wind. There are also a number of patented and unpatented devices to catch these insects by machinery, which jar the tree, collect the beetles, and grind them up. More can not be expected from one machine! A very simple contrivance to collect the beetles is shown in Fig. 214. *All fallen fruit should be picked up* is a rule that should be strictly followed in every orchard. If the owners of trees have no time for this purpose, let them permit turkeys and chicken to do so; even hogs and sheep may be useful.

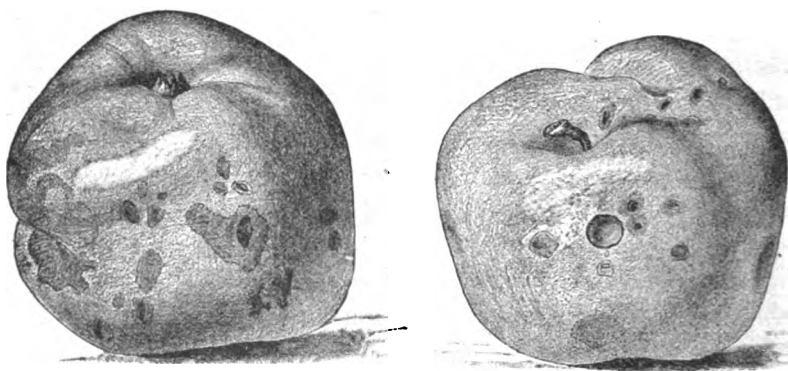


Fig. 215.—*Conotrachelus nenuphar*, Hbst; punctures in apples. After Division of Entomology, U. S. Department of Agriculture.

There are many other methods in vogue, and a few of them are of some use. Shingles laid close to the trunk of a tree, the fruits of which are to be protected, will early in the spring offer a shelter for the beetles that have fed upon the trees during the night, and which, towards morning, leave it—on foot—to hide during the day. By turning over and inspecting these traps one can destroy many beetles.

Although the curculio is well protected as long as still enclosed by the plum, it has nevertheless many enemies, and these destroy large numbers of the full-grown larvæ of the "Little

Turk" when they leave the fruit to enter the ground for pupation. Other insects actually eat into the fruit as it lies upon the ground, to seize the larvæ, drag them out, and eat them. Some of the ground-beetles mentioned before are of great assistance to the fruit-growers, and the *Harpalus pennsylvanicus* De G., illustrated in Fig. 22, is of special importance, as it is very common in our orchards. Its larva is illustrated in Fig. 216, in the act of devouring a curculio larva. Other members of this useful family of insects are also good friends, and should be known as such.

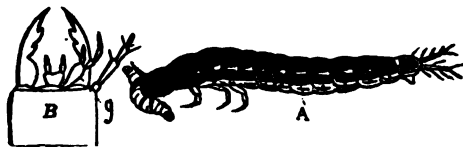


Fig. 216.—*Harpalus pennsylvanicus*, DeG; larva. After Division of Entomology, U. S. Department of Agriculture.



Fig. 217.—*Chauliognathus americanus*, Forst.; larva and adult. After Riley.

Fig. 217 shows the larva and adult of one of our most common soldier-beetles, *Chauliognathus americanus* Forst. The beetles themselves occur in large numbers on the flowers of the golden-rod; they are yellowish with black markings, as shown in the illustration. Their larvæ frequently work their way into the plum in search of their prey and do this even while the fruit is still on the tree.

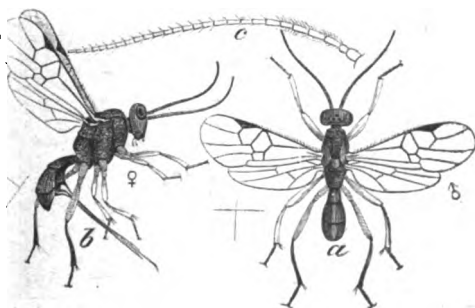


Fig. 218.—*Sigalphus curculionis*, Fitch; a, male; b, female. After Division of Entomology, U. S. Department of Agriculture.

The larvæ of the "lace-wing flies" are also fond of such fat morsels as the larvæ of the plum curculios, and are not slow to utilize such food whenever they can obtain it.

Ants of many kinds destroy the helpless larvæ as these leave the fruit to enter the ground, and if the latter is kept free of weeds and dusty, many perish before they succeed in entering it. This again shows that clean culture is of benefit in many ways!

It is stated that large numbers of eggs of the curculio are eaten by a minute yellow Thrips, scarcely one-twentieth of an inch long.

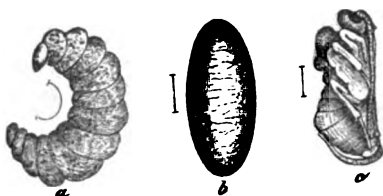


Fig. 219.—*Sigalphus curculionis*, Fitch; a, larva; b, cocoon; c, pupa. After Division of Entomology, U. S. Department of Agriculture.

Besides such cannibal insects we possess other friends, which are true parasites. At least two species are described, both illustrated in Figs. 218, 219, and 220. In some years such parasites are fairly common, and do good work, but as a general rule they do not appear in sufficient numbers to act as an efficient check, and there is but little doubt that if we wish to eat fine plums we will have to work for them, otherwise the curculio will certainly take more than the lion's share.

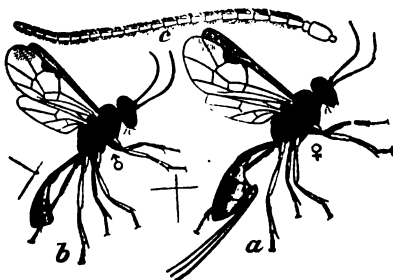


Fig. 220.—*Porison conotrachell*, Riley; a, female; b, male. After Division of Entomology, U. S. Department of Agriculture.

THE WALNUT CURCULIO.

(*Conotrachelus juglandis* Lec.).

Looking at the adult of this beetle we are apt to imagine that we have before us simply a very large specimen of the plum-curculio, with the white band across the posterior portion of the wing-covers whiter and more clearly marked. The sealingwax-like projections, which form such a distinctive feature in *nenuphar* are also present, while in all other species of the large genus *Conotrachelus* they are either simply indicated or entirely absent.

The injury caused to our native walnuts and butternuts by these beetles is considerable, as they frequently take more than the lion's share, so that no nuts are left for our use. Infested nuts show the presence of the worm inside by a discolored spot upon the green husk, from which dark-colored masses not infrequently project.

Several other species occur, for instance *C. crataegi* Walsh, in the fruits of hawthorns; *C. elegans* Say, in the partly rolled up leaves of the pig-hickory, which being cut off hang down, wither and turn black; *C. naso* Lec., and *C. posticatus* Say, in the fruit of the haw.

THE QUINCE CURCULIO.

(*Conotrachelus crataegi* Walsh).

As already mentioned this beetle is found in Minnesota, and eats in its larval stage the fruits of the hawthorn; but in the east it has become rather destructive to the quince. As may be seen from the illustration (Fig. 221), it is a broad-shouldered snout-beetle, larger than our enemy, the plum curculio, possessing also a larger snout. It is of an ash-gray color, mottled, in fresh specimens with ochre-yellow or white, with a dusky and almost triangular spot at the base of the pro-thorax; there are seven narrow longitudinal ridges on the elytra, with two narrow rows of rather deep pits between. It is most commonly found during the month of June, when it punctures the young fruit, making a cylindrical hole a little larger than is sufficient to admit the egg;

the hole is a little enlarged at the base. In it the egg hatches into a larva, which does not, however, penetrate to the core, but burrows in the fruit near the surface.

The larva, a little larger than that of the plum curculio, and having a narrow dusky line down the back, matures in about four weeks, when it leaves the quince by a cylindrical opening and drops to the ground. Into this it burrows to a depth of several inches, remaining there until spring, when it transforms to a pupa, and soon afterwards to a beetle. This also feeds upon the quince, sometimes penetrating deeply into it. It also occasionally attacks the pear.

Like the plum-curculio it can be collected in large numbers by jarring; fruit infested, which falls prematurely to the ground, should also be gathered and destroyed.

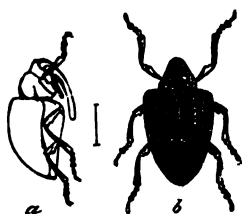


Fig. 221.—*Conotrachelus crataegi*, Walsh. After Riley.

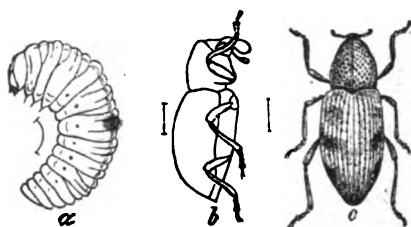


Fig. 222.—*Tyloderma fragariae*, Ril. After Riley.

It seems that all members of the genus *Conotrachelus* possess similar food habits, and many other plants besides the fruit-producing ones are infested; for instance, the *C. fissunguis* Lec., so frequently found along the shores of tide water swamps in the showy flowers of the *Hibiscus*, feeds as a larva in the bolls of that plant.

There are some species of a closely allied genus, (*Chalcodermus*), which are found as beetles upon the fruit of the dewberry and blackberry, which they destroy. The writer has also seen them in large numbers upon human excrement containing the seeds of these berries.

THE STRAWBERRY CROWN-BORER.

(*Tyloderma fragariae* Ril.).

These beetles are not frequently seen, but the work of their larvæ is apt to become very prominent, as all strawberry plants infested by them are sure to perish. The beetle, shown in Fig. 222, is about one-sixth of an inch long, of a leathery-brown color, with two large black spots on the sides of the elytra, which spots are set off very clearly in fresh specimens, as in such cases they are bordered with heavy white scales, which, however, have almost disappeared in older ones. The prothorax is deeply and uniformly pitted.

Like a number of similar and closely allied beetles, it pretends to be dead when disturbed, and plays possum most perfectly, having the rather short and thick beak completely hidden beneath the head and thorax, and the legs are folded together and bent at the same time so that no one would believe that this object could be a living insect. The beetles appear in June and July, and deposit eggs about the crown of the strawberry plant; when hatched the young larvæ enter the crown, burrow downward, and bore and excavate the substance of the crown until full grown, when they appear as represented at *a* in the illustration. After changing to a pupa the adult beetle appears during the month of August.

Old strawberry plants are more liable to injury than new ones, and the only remedy we possess is to dig up and burn the plants suspected of containing such larvæ as soon as the fruiting season is over.

A number of similar beetles occur in flowers and upon the grape-vine, but as far as known cause no injuries. Both the polished black *T. aereum* Say, and the rougher *T. foveolatum* Say, which is ornamented with white scales arranged in spots, lines, and bands, are common in Minnesota.

The illustration, (Fig. 223, Plate III.), shows a very remarkable snout-beetle (*Tachygonus Lecontei* Gyll.), which feeds on the leaves of oak. It gave the writer a good illustration of the truth of

the old maxim: "there is nothing new under the sun." He found a specimen of this odd-looking being, and wondered why it should possess such long legs, and of such peculiar shape. By spending much time he discovered that the beetle in flying to a young oak tree near by approached the under side of a leaf and threw the legs upwards when they performed the action of an anchor and fastened the insect to the desired spot. When writing down his observations he happened to consult a very old entomological work, and found to his intense surprise—and disgust—that this fact had already been recorded in the year of his birth.

THE GRAPE CURCULIO.

(*Craponius inaequalis* Say).

This almost globular snout-beetle, illustrated in Fig. 224, is by no means common in our state, but has been repeatedly taken from grapes, hence should be mentioned. It is only about one-

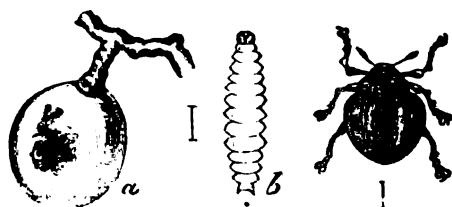


Fig. 224.—*Craponius inaequalis*, Say. After Riley.

tenth of an inch long, black, thickly punctated, and sprinkled with scales forming grayish spots or dots. It seems to pass the winter in the perfect state, laying eggs on the young berries of the grape during June or early in July. The young larva enters the berry and feeds upon it, showing its presence by a discoloration on one side of the same. A dark circular dot can be detected in this discolored spot, which indicates where the larva has entered. Notwithstanding this injury, the affected berry does not decay, but remains sound and hard, although it sometimes drops to the ground before it is fully ripe. The enclosed yellowish-white and translucent larva is an elongated footless grub, with a large, horny,

brownish-yellow head, which reaches its full size late in July or early in August, when it drops to the ground, and entering the same changes to a pupa, and later to a beetle.

Much of the injury caused to the berries of the grape is caused by a small moth, the grape-berry moth, illustrated in the "Fourth Annual Report," and not all the blame should be laid at the door of this beetle, which is seldom numerous enough to cause any serious injury. If this should ever happen it can be gathered by jarring the vine over an inverted umbrella.

Similar in size, shape and general markings are a large number of snout-beetles found in Minnesota. None of them are of much economic importance, with the exception, perhaps, of one species, which forms gall-like swellings on the roots of cabbage. To show their appearance the illustration, (Fig. 225), is reproduced.

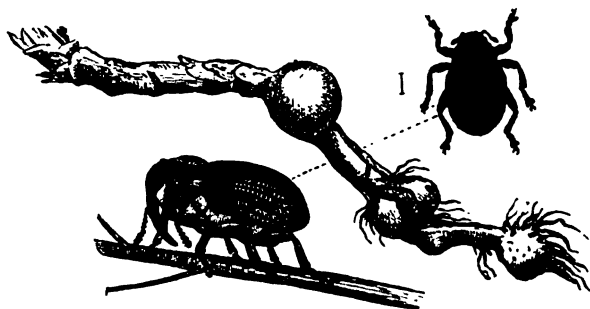


Fig. 225.—Cabbage Curculio. After Brehm

There is another large group of snout-beetles, some members of which are very numerous in Minnesota, that deserve a passing notice, and the description of a few injurious ones will be given, which, with the illustrations, will give a general idea as to how they appear.

THE POTATO-STALK BORER (*Trichobaris 3-notata* Say) is fairly common. It is a small ash-gray snout-beetle, about one-sixth of an inch in length, with a black snout and three small

black spots at the base of the wing-covers (Fig. 226). The ash-gray color is produced by the numerous scales of that color, which uniformly cover the beetle, and the black spots, sometimes very plainly marked but in other cases entirely absent, seem to be produced by the removal of such scales. Western species are mostly unicolored, eastern possess three larger or smaller spots. This beetle deposits eggs in the stems and larger branches of the potato, Jimpson weed, and perhaps other *Solanaceae*; the resulting white larvæ feed there until midsummer, when, at the time the

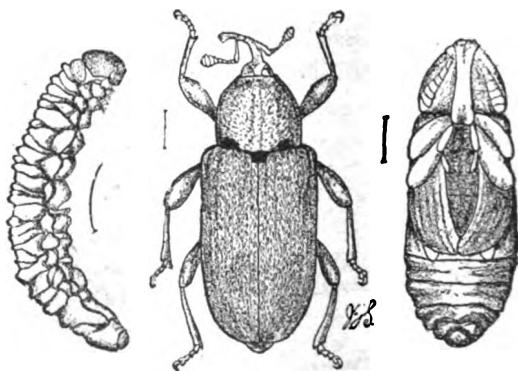


Fig. 226.—*Trichobaris 3. notata*, Say. After Smith.

plant matures, they change to pupæ and beetles, the latter remaining in the burrows until spring. Knowing their life-history it is of course very simple to suggest the proper remedy, i. e., to burn the dead potato-vines as soon as the crop is harvested.

Many other and similar snout-beetles are found, which, as a rather general rule, are polished black, with numerous fine striæ upon their wing-covers.

THE GRAPE-VINE GALL-BEETLE.

(*Ampelogypter Sesostris* Lec.).

This, as well as *A. ater*, produces curious gall-like swellings on the stems of the grape-vine, which have received the name *Vitis vulnus* Ril. Such galls are not uncommon on the wild and

cultivated grape vines, being elongated knots or swellings, usually situated immediately above or below a joint, as shown in Fig. 227. Frequently the gall shows a longitudinal depression on one side, dividing it into two prominences, usually distinguished by a rosy tint. The architect of such a gall is a small beetle about one-eighth of an inch long, of a reddish-brown to black color, with a rather stout beak, half as long as its body. The entire beetle is highly polished; the thorax is punctated, and the wing-covers are without any markings, but have a sort of wavy surface, in certain lights producing the effect of being marked as shown in the illustration. The adult insect is found early in July; the female at this time punctures the stem of the vine, and deposits an egg which

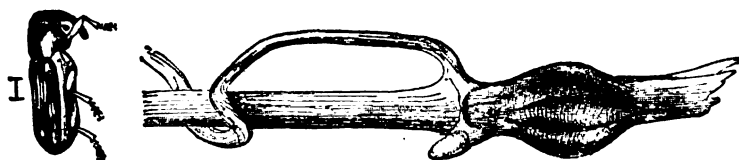


Fig. 227.—*Ampelogypter Sesostris*, Lec. After Riley.

soon hatches into a whitish grub that feeds within the swollen part of the vine. It remains inside the gall until June of the following year. A full grown larva is about a quarter of an inch long, white, cylindrical, footless, with a large yellowish head. During June it changes to a pupa, and soon afterwards to a perfect beetle.

These beetles are not numerous enough to cause any extensive damage, and as the galls can readily be seen, they can be cut off and burned. Since we trim our vines in the autumn, before burying them in the ground to prevent freezing, there is no danger that this snout-beetle should ever become injurious, and especially if we gather the cut off vines and burn them. Our numerous wild grapes, however, will always produce a crop of such beetles.

A related species, the *A. ater* Lec., which is very similar to the *Sesostris*, forms gall-like swellings on the leaf-stalks of the

Virginia creeper, and in this case at least the beetles mature inside them before the summer is past, indicating, perhaps, that it is double-brooded.

Still another similar but larger beetle is frequently found upon the grape vines and other plants; it is *Madarus undulatus* Boh. and is a very singular looking insect, very highly polished, entirely black, and with a bright reddish pro-thorax. The surface of the wing-covers are undulating, hence the specific name.

The genus *Balaninus* contains a number of very peculiar beetles, frequently called "Nut-weevils" (Fig. 228). All of them



Fig. 228.—Nut-weevil. After Brehm.

confine their attention to the different kinds of hazelnuts, chestnuts, acorns, and hickory nuts; hence are injurious where nuts as chestnuts and pecans are grown for the market.

In Minnesota we have a large number of such beetles, and the lover of freshly-picked hazel nuts is frequently greatly disappointed in finding a fat worm instead of a sweet kernel. People buying chestnuts are equally disgusted with their bargains and for the same reason. The great majority of acorns are equally infested. All our species of *Balaninus* are large beetles.

THE CHESTNUT WEEVIL.

(*Balaninus caryatrypes* Boh.).

As this species shows the forms of all members of this genus it is described and illustrated in Fig. 229. It is the largest, and like the others, of a clay-yellow color, marked with brown spots arranged in wavy lines. It has an exceedingly long and slender black beak, which in the female is longer than the entire insect, and is gracefully curved; in the male the rostrum is not much longer than the wing-covers. Dr. Le Conte, in his work on "The Rhynchophora of America," remarks that the beak of these beetles attains in length and attenuation the greatest development;

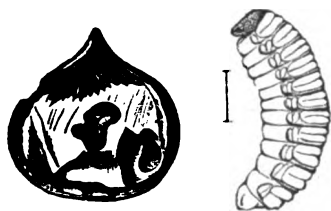


Fig. 229.—*Balaninus caryatrypes*, Boh.
After Division of Entomology, U. S.
Department of Agriculture.

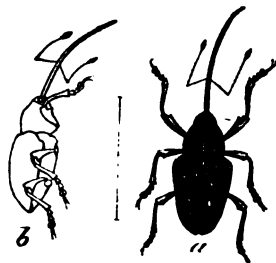


Fig. 230.—*Balaninus rectus*, Say.
After Division of Entomology, U.
S. Department of Agriculture.

in the male it is rarely shorter than the body, in the female it is frequently twice the length, and is used to make the perforation into which the egg is subsequently introduced. The great thickness of the husks of the fruit, (chestnuts, walnuts, hickory nuts, etc.) attacked by these insects necessitates a very long perforating instrument to reach the kernel upon which the larva feeds. The chestnut is often badly infested by this large white maggot with a yellowish head, which attains its full size at the time the nuts drop. It is found in nuts sent to the market, and it is probable that while some of the maggots gnaw their way out, and enter the ground in the autumn to transform, others delay until the spring, and this is but natural, as the adults are found almost throughout the warmer portions of the year, depositing eggs dur-

ing the greater part of this period. The worms devour nearly one-third or one-half of the interior of the nut, part of the cavity being filled with the castings of the worm. As the grub is white it is liable to be overlooked and eaten with the chestnut; when mature it leaves through a round hole and drops to the ground, into which it enters to some depth, and here it hibernates, changing to a beetle in the spring.

People in more southern regions, who raise chestnuts for the market, lose considerably by the attacks of this grub. The only remedy against the beetle consists in gathering the nuts as soon as they fall, and either shipping them at once, or else storing them in tight boxes and barrels, from which the larvæ can not escape. Here they gather in large numbers at the bottom, and can easily be killed with boiling water.

We have a number of species, which are found in acorns. *B. rectus* Say, one of them, is illustrated in Fig. 230.

FAMILY BRENTIIDAE.

(*Brethids*).

Only a single species is found in our state, the family being confined to tropical regions, where a large number of very peculiar forms exist. Our species, the *Eupsalis minuta*, Drury, although

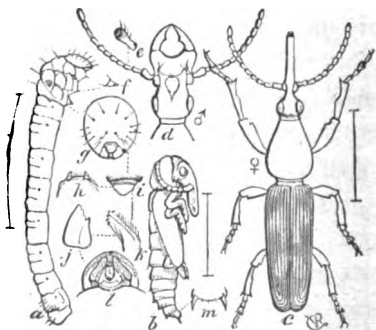


Fig. 231.—*Eupsalis minuta*, Drury. After Riley.



Fig. 232.—*Brentus anchorago* Linn; male and female. After Brehm.

quite odd in appearance, does not give a good idea of its southern relatives, some of which are exceedingly long, almost linear. *E. minuta* (Fig. 231), occurs as larva in the solid wood of oak-trees. The male of the adult insect possesses a broad and flat snout, equipped with powerful jaws; the female has the head prolonged into a slender one. The males fight desperately with their beaks, and are even said to assist the females in forcing their slender beak into the solid wood by grasping it with their own, so that with united strength a hole for the reception of the egg is formed. Fig. 232 shows the two sexes of such interesting insects from warmer regions.

FAMILY CALANDRIDAE.

(*Bill bugs; Grain-weevils.*)

In this family the lateral edge of the meta-thorax and of the abdomen fits into a groove in the wing-cover, the surface of this groove has a pearly luster. The pygidium of both sexes is undivided, and may be covered or uncovered by the wing-covers, but it is not surrounded by them at the edge, as in the Scolytidæ; the tibiæ are not serrate; the antennæ are elbowed; and the labrum is wanting. The larvæ of the larger species bore into the stems of plants, while those of the smaller species infest grains and seeds. (Comstock).

As none of these beetles are destructive to fruit producing plants, only a few of the better known and most destructive kinds will be described and illustrated.

The large genus *Sphenophorus* is well represented in our state and many species are found, especially along the shores of our lakes, where they occur at certain seasons in remarkably great numbers.

The most common species are *S. ochreus* Lec., and *S. costipennis* Horn. The former feeds in the roots of *Scirpus*, and is shown as larva and adult (Fig. 233). It varies greatly in color, but perfectly fresh specimens are ochreous, marked with whitish and blackish longitudinal lines.

Prof. Smith writes as follows about such beetles: "In many localities corn is attacked soon after it shows above ground by insects known as 'Corn Bill-bugs.' (In eastern Maryland and Virginia they call corn injured by such beetles 'Frenchy,' in the same way in which they call the Thrasher, a singing bird inferior in song to the Mocking-bird, the 'French Mocking-bird'). These belong to the genus *Sphenophorus*, and are blackish or brown, rarely gray in color, varying from one-fourth to one-half an inch in length, with very thick and hard wing-covers, which

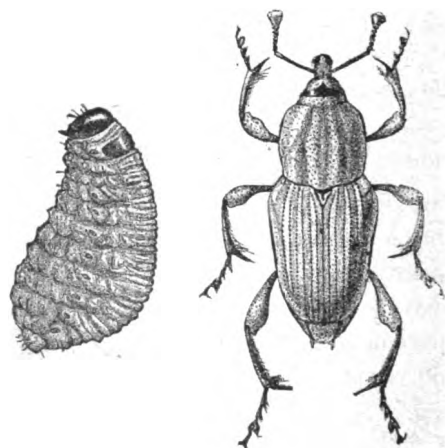


Fig. 233.—*Sphenophorus ochreus*, Lec.; larva and adult. After Division of Entomology, U. S. Department of Agriculture.

are ridged and punctured, as is also the thorax. They hide in the soil at the base of the corn-plants during the day, and kill them by boring little round holes in the stem. They are most frequently after timothy, especially on old sod; or when corn follows sedges or bulb-rooted grasses. It is in such places that the larvae live naturally, pupating in fall or early spring, and the beetles, finding that their natural food is gone on spring plowed land, attack the corn, which replaces it, and is nearly enough like it to be to their taste. The period of injury is usually short, and if replanting is delayed a little, the new shoots escape attack. Fall-plowing old timothy-sod or sedge-land is always indicated, and

will generally serve to reduce if it does not entirely prevent injury."

Some other closely related beetles are only too well known. They are the grain and rice-weevils, belonging to the genus *Calandra*. These insects, similar in shape to those just mentioned but hardly exceeding one-eighth of an inch in length, infest stored grain of all kinds and have become almost cosmopolitans, being brought to nearly all parts of the globe by commerce. They are black or brownish-red, sometimes marked with lighter-colored

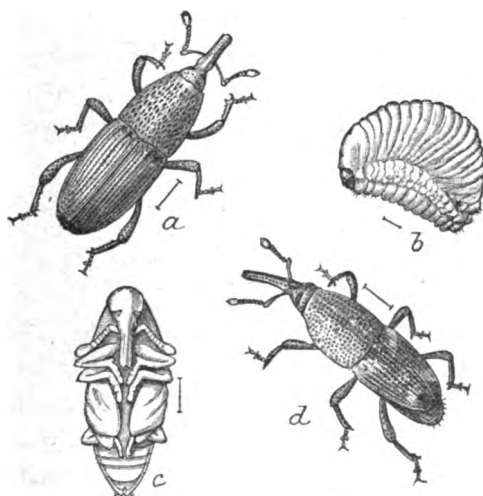


Fig. 234.—*Calandra granaria*, Linn.; a, beetle; b, larva; c, pupa; d, *C. oryza*, Linn.—All enlarged. After Division of Entomology, U. S. Department of Agriculture.

spots as indicated in the illustration (Fig. 234d). Wherever grain of all kinds, or rice, is stored for any length of time, these insects are sure to be attracted, and are as certainly apt to multiply very rapidly, so that before long the grain-bins are overrun by myriads of them. In some mills, breweries and similar places they are so numerous that they become a very great pest, and it is difficult to get rid of them in such places. The only prevention is cleanliness and the rapid removal of stored grain. They prefer dark places, therefore a flood of sunlight will prevent their rapid increase. After removal of the grain all cracks should be

made tight, so as to do away with hiding places. In bins that can be made fairly tight, these insects can easily be controlled by the use of bisulphide of carbon. This is poured on the grain, covering it afterwards with canvas or any other similar material to prevent the too rapid escape of the fumes, which, being heavier than air, gradually permeate the entire mass, killing everything in it without causing any injury to the seeds themselves. It is best to do this work after working hours, at all events away from any fire, as the fumes of this chemical are inflammable, and may otherwise kill the insects in a most unexpected, though very effective way.

Numerous other and similar insects are often found under the bark of trees, especially that of the pine. All such beetles are very similar in shape, most are highly polished, others are roughly punctured and gray.

FAMILY SCOLYTIDAE.

(*Bark-beetles, Engraver-beetles*).

"Engraver-beetles" are so named because they make burrows of more or less regularity between the bark and the sap-wood, as may be seen in the illustration, (Fig. 235), which illustrates the work of the Hickory-bark Borer, (*Scolytus 4-spinosus* Say). Some of these beetles are also called "shot-hole borers," from the little round holes with blackened edges which they make in wood and bark; and still others are called "Ambrosia Beetles," because the insects actually plant the spores of a fungus in the burrows made in solid wood upon which they and their larvæ live. Most of the members of this large family attack forest trees, and those interested in them should read the excellent work of Dr. Packard, already referred to.

Bark-beetles are mostly small, some almost microscopic, the larger ones rarely exceeding a quarter of an inch in length. Their form is cylindrical, the hind end of the body is frequently very blunt, or even cut off squarely; the feelers are short; elbowed or bent in the middle, ending in knobs at the tip; the tibiæ are usu-

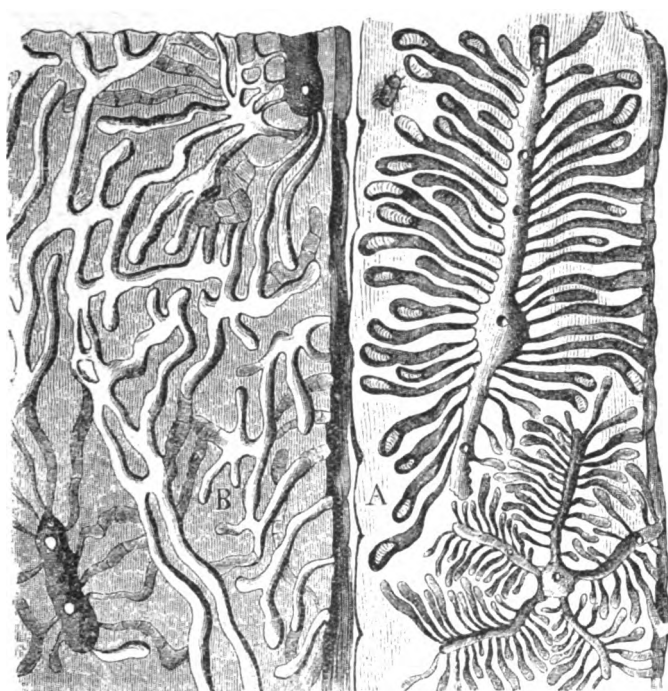


Fig. 235.—a, work of *Bostrichus*; b, that of *Eccoptogaster*. After Brehm.

ally serrate, and the pygidium is surrounded at the edge by the wing-covers, which have the fold on the inner side well developed. In many cases the edges of the declivity of the wing-covers are toothed or serrated in various ways, though in others they are normal. They also differ from the other snout-beetles in possessing a very short snout, which is scarcely more than a slight prolongation of the head.

The larvæ are similar to those of the genuine *Curculionidæ*, but have stronger jaws to adapt them for boring into hard wood. Their method of doing so is very peculiar, and differs in the different genera composing this family. Some bore between the bark and solid wood, several working from a common center; the burrows, which gradually widen to the place of exit, radiate

in all directions, making fanciful carvings and engravings on the inner side of the bark and the surface of the wood, hence the name "engravers."

Many species have a habit similar to the one quoted by Prof. Comstock from Dr. Lindemann, who writes: "that in the case of *Tomicus typographus* the original tunnel is begun by the male, who makes a little chamber in the bark; afterwards the female comes to him in this chamber, and later she continues the mine begun by her mate, making the long central tunnel from which the tunnels of her off-spring extend. Thus we see that all the members of a single family have a share in making one of these engravings."

Whenever a tree has been invaded by a number of such insects the trees are killed, and in other cases the timber is greatly injured by the burrows in the solid wood. It seems as if these beetles preferred sick or dying trees, in which case they act simply as scavengers, removing the dead material to make room for new growth. Beside forest trees, fruit-trees are also attacked by some members of this large family, and in some very few cases even the roots of the clover suffer.

Those interested in such beetles should not fail to read the important work of Dr. A. S. Packard, published by the U. S. Department of Agriculture, entitled: "Insects Injurious to Forest and Shade Trees," or the most interesting paper on "Ambrosia Beetles" by H. G. Hubbard in a recent bulletin (No. 7) of the Division of Entomology, Washington, D. C., and the valuable bulletin (No. 56) of the West Virginia Experiment Station by A. D. Hopkins.

THE APPLE BARK-BEETLE.

(*Monarthrum mali* Fitch).

In the genus *Monarthrum* the sexes are alike, and the males assist the females in forming new colonies. Mr. Hubbard writes: "The young are raised in separate pits or cradles, which they never leave until they reach the adult stage. The galleries, con-

structed by the female beetles, extend rather deeply into the wood, with their branches mostly in a horizontal plane (Fig. 236).

"The mother beetle deposits her eggs singly in circular pits which she excavates in the gallery in two opposite series, parallel with the grain of the wood. The eggs are loosely packed in the pits with chips and material taken from the fungus bed, which she has previously prepared in the vicinity, and on which the ambrosia has begun to grow.

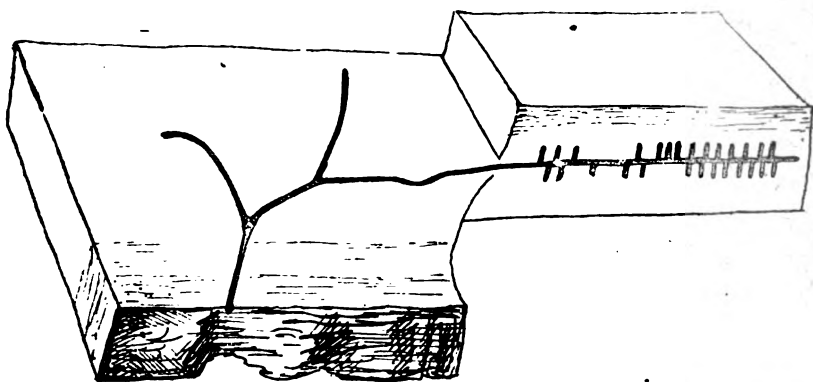


Fig. 236.—Burrows of *Monarthrum mali*, Fitch. After Division of Entomology, U. S. Department of Agriculture.

"The young larvæ, as soon as they hatch, eat the fungus from the chips, and eject the refuse from their cradles. At first they lie curled up in the pit made by the mother, but as they grow larger they deepen their cradles with their own jaws, until, at full growth they slightly exceed the length of the larva when fully extended. The larvæ swallow the wood which they excavate, but do not digest it. It passes through the intestines unchanged in cellular texture, but cemented into pellets by the excrement, and is stained a yellowish color. The pellets of excrement are not allowed to accumulate in their cradles, but are frequently ejected by them, and are removed and cast out of the mouth of the boring by the mother beetle. A portion of the excrement is evidently utilized to form the fungus garden bed. The

mother beetle is constantly in attendance upon her young during the period of their development, and guards them with jealous care.

"The mouth of each cradle is closed with a plug of the food fungus, and as fast as this is consumed it is renewed with fresh material. The larvæ from time to time perforate this plug and clean out their cells, pushing out the pellets of excrement through the opening. This debris is promptly removed by the mother, and the opening again sealed by ambrosia. The young transform to perfect beetles before leaving their cradles and emerging into the galleries.

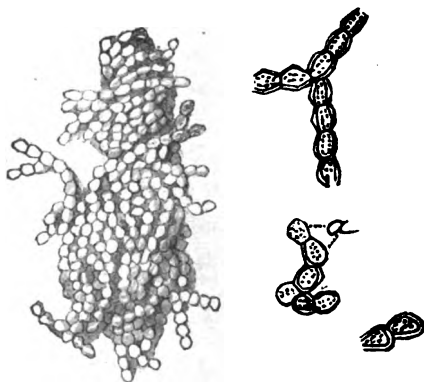


Fig. 237.—Ambrosia of *Corthylus punctatissimus*, Zimm.; a, detached bumb-bell shaped pairs of cells, greatly enlarged. After Division of Entomology, U. S. Department of Agriculture.

"The Ambrosia of *Monarthrum* (Fig. 237), is moniliform, and resembles a mass of pearly beads. In its incipient stages a formative stem is seen which has short joints that become globular conidia and break apart. Short chains of cells, sometimes showing branches, may often be separated from the mass. The base of the fungus mass is stained with a tinge of green, but the stain in the wood is almost black.*

"Two species, *M. fasciatum* Say, (Fig. 238), and *M. mali* Fitch (Fig. 239), are confined to the Atlantic forests, and range in latitude from Lake Superior to Florida. They have identical

*By mistake the ambrosia of another closely related beetle has been illustrated.

habits, and feed upon the same fungus. They are commonly associated in the same tree-trunk, and not seldom occupy galleries having a common entrance hole. Both species are known to attack wine casks, but they probably breed only in dying trees."

The trees attacked include oak, hickory, beech, maple, aspen, apple and orange, and the list might be extended to include other hardwood timber.

According to Fitch the insects sometimes attack young and thrifty trees, which, when badly affected, are apt to suddenly wither soon after putting forth their leaves, as if scorched by fire; the bark becomes loosened from the wood, and soon afterwards these small beetles appear crawling through minute perforations, like large pin-holes, in the bark.

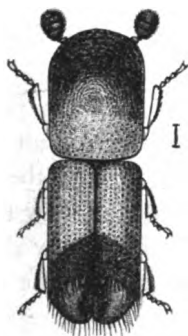


Fig. 238.—*Monarthrum fasciatum*, Say. After Division of Entomology, U. S. Department of Agriculture.

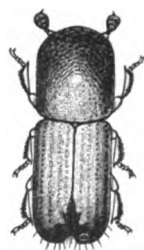


Fig. 239.—*Monarthrum mali*, Fitch. After Division of Entomology, U. S. Department of Agriculture.

From the above description by Mr. Hubbard it is seen that such beetles are genuine gardeners, since they do not consume wood but minute and juicy fungi propagated on the walls of their galleries. All the growing parts of the fungus are extremely succulent and tender, but remain in that condition only when continually cropped; if allowed to go to seed it is no longer useful as food. Mr. Hubbard also states that when their galleries are disturbed and opened to day-light, the adult beetles generally fall to eating their ambrosia as rapidly as possible. Like other social

insects they show their concern at the threatened loss of their most precious possession by trying to save it, just as bees, when alarmed, fill themselves with honey.

As far as remedies are concerned, it is evident that any method by which the entrances of their galleries in the bark can be closed, will effectually put an end to the progress of their colonies, and perhaps the best means to do so is by coating the trunks with dendrolene or "raupenleim." Valuable fruit-trees, which have suffered from fire or frost, can not be protected in this manner, as the buds, which must be allowed to grow on the trunks, would be injured or destroyed. In such cases it is best to plug the holes with a piece of wire, which is inserted as far as it will go and then cut off.

THE PEAR-BLIGHT BEETLE.

(*Xyleborus pyri* Peck).

During the heat of midsummer the twigs of the pear-tree sometimes become suddenly blighted, the leaves and fruit wither, and a discoloration of the bark takes place, followed by the speedy death of the affected part. This trouble is not caused by the well known fire-blight, which is a disease and is of a totally different character, and is entirely independent of any insect. The injuries

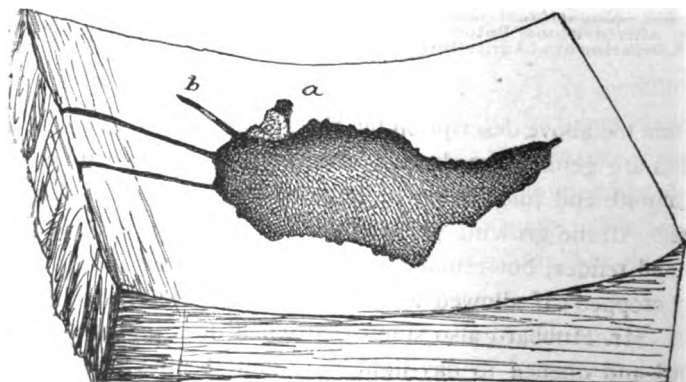


Fig. 240.—Gallery of *Xyleborus xylographus*, Say; in hickory; a, b, death chambers. After Division of Entomology, U. S. Department of Agriculture.

are not confined wholly to the pear, but the same insect occurs also on the apple, the plum, and the apricot.

According to Hubbard the members of this genus of beetles also exist upon ambrosia, which is grown by the females for the purpose of feeding the young, as has already been described.

Each species of beetle grows its own kind of ambrosia, and the galleries made are of a different character, as may be seen in the case of *X. xylographus* Say, illustrated in Fig. 240, where the young are assembled in a large brood chamber, constructed at the end of a gallery which penetrates deeply into the heart of the tree, or remains in the sap-wood, according to the amount of moisture in the trunk. The chamber is somewhat leaf-shaped, and stands vertically on edge, parallel with the grains of the wood.

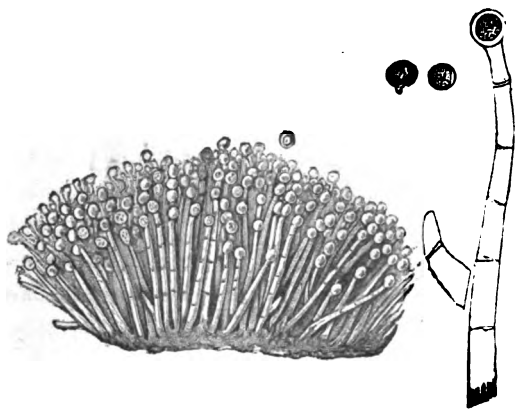


Fig. 241.—Ambrosia of *Xyleborus xylographus*, Say. After Division of Entomology, U. S. Department of Agriculture.

The space between the walls is not much greater than the thickness of the bodies of the adult beetles. The larvæ of all ages are able to cling to the vertical walls, and to progress over them by an adaptation of the end of the body, which aids them in advancing. The entire surface of the walls in the brood chamber is plastered over with ambrosia fungus, a representation of which is given in Fig. 241. It consists of short, erect stems, terminating

in spherical conidia. The freshly grown fungus is colorless as crystal, but it is usually more or less stained with greenish-yellow, and sometimes looks like a coating of sublimed sulphur. The brood chamber is at times packed with eggs, larvæ, pupæ and adults, in all stages of maturity. The larvæ aid in extending the brood chamber. They swallow the wood which they remove with their jaws, and in passing through their bodies it becomes stained a mustard-yellow color. Great quantities of this excrement are ejected from the openings of the colony, but a portion is retained and plastered on the walls, where it serves as a bed upon which a new crop of the fungus springs up. In populous colonies it is not unusual to find the remains of individuals who have died packed away in a deep recess of the brood chamber, carefully enclosed

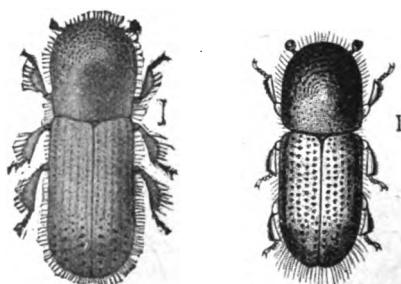


Fig. 242.—*Xyleborus xylographus*, Say; female and male. After Division of Entomology, U. S. Department of Agriculture.

with a wall of chips. At *a* in Fig. 240 such a catacomb is shown, which was found to contain the mutilated bodies of a dozen or more larvæ and immature imagos, together with the fragments of a predatory beetle, *Colidium lineola* Say. This tomb bears testimony to a sanguinary conflict in which victory crowned the efforts of the ambrosia beetles. The bodies of the slain, both friend and foe, have been consigned to the same sepulchre. In the same figure, at *b*, a short branch of the gallery is shown containing the lifeless body of the mother of the colony, who appears to have constructed her own tomb, and to have crawled into it as she neared her end. The mouth of this tomb has also been sealed

up by the survivors. Both male and female of *Xyleborus xylographus* Say are shown in Fig. 242.

A number of very minute beetles, belonging to the genera *Hypothenemus*, and *Pityophthorus*, mine under the bark of the apple, walnut, hickory, chestnut, and others. None are very destructive, however, as they are usually found in dead or dying twigs, and none of them have such interesting habits as the ambrosia-beetles, since their food consists of wood and not of fungus grown by the mothers.

THE FRUIT BARK-BEETLE.

(*Scolytus rugulosus* Ratz.).

This beetle, not yet found in Minnesota, but uncomfortably near it, needs a description, so that fruit-growers may recognize this pest in time to combat it successfully. Prof. Smith gives a full account of it in his text-book already mentioned, which is here quoted :

"*Scolytus rugulosus*, the 'fruit-bark beetle,' is, perhaps, the best known, and certainly the most important economically, attacking deciduous forest trees of almost all kinds. The black parent beetles appear in early spring, and bore little round holes through the bark to the sap-wood. They then make a central burrow, on each side of which little notches are made to receive the soft white eggs. The larvæ hatch very soon, and at once begin to make little burrows of their own, diverging as they move from the parent channel, and gradually enlarging them as they increase in size. When full grown they form a slightly enlarged chamber, in which they pupate, and when they transform to little beetles make their way out through little round holes in the bark. The whole period of development does not exceed a month, and there may be several broods during the summer from the same tree, the numerous galleries eventually girdling and killing it.

"These insects rarely attack sound and healthy trees, and this is a peculiarity of bark-beetles in general, though there are many exceptions. But just as soon as a tree becomes a little weakened

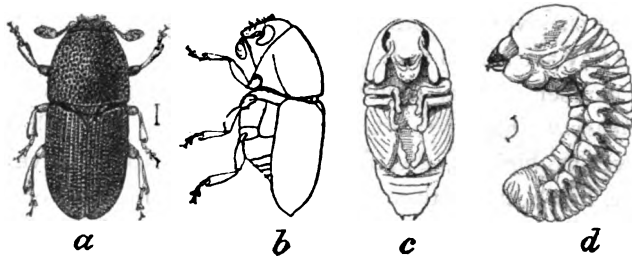


Fig. 243.—*Scolytus rugulosus*, Ratz.; a, adult; b, same in profile; c, pupa; d, larva. After Division of Entomology, U. S. Department of Agriculture.

through injury or from starvation, these little creatures attack it, and then its doom is sealed, unless vigorous measures are taken at once. Peach trees are especially susceptible to injury, and the gummy oozing from the little holes seems to weaken them so rapidly that they succumb in a short time.

"It is good practice to keep orchard trees in the best possible health and vigor at all times to enable them to resist naturally

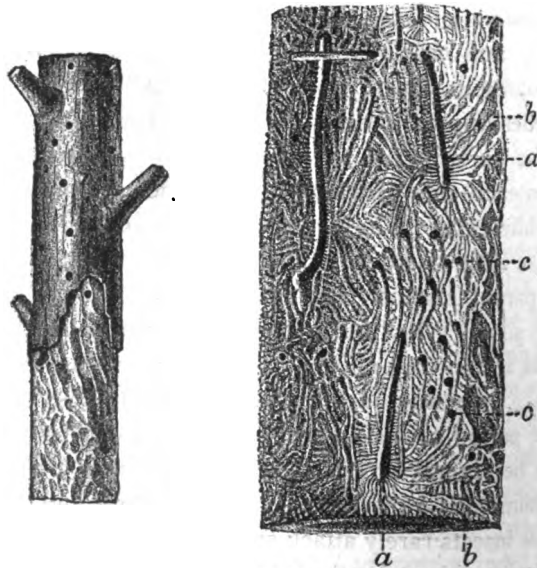


Fig. 244.—Work of *Scolytus rugulosus* in twig of apple; and to the right, galleries under bark; a, a, main galleries; b, b, larval galleries; c, c, pupal cells. After Division of Entomology, U. S. Department of Agriculture.

the attacks of these insects, but if one does become seriously infested it should be at once cut out and burned. It is certain to die in a short time, and it is a constant menace to surrounding trees from the abundance of specimens which will be produced, ready to attack others at the least sign of weakness. Where a slight infestation is noticed on a tolerably healthy tree, it should be closely examined to ascertain the original source of weakness, and when this is removed the tree should be stimulated by means of appropriate fertilizers, and the trunk kept covered by white-wash to which Paris-green has been added. Strong whale-oil soap-suds will answer the same purpose, and a little crude carbolic acid will add to its effectiveness. In all cases the application should be thorough, and should be kept intact until the tree has fully recovered and is able to take care of itself. The beetle is shown in Fig. 243, and its burrows in Fig. 244."

The same line of treatment is adapted to other bark-beetles, varied according to the differences in life-history.

THE HICKORY-BARK BEETLE.

(*Scolytus 4-spinosus* Say).

This beetle confines its work to all kinds of hickory, in which it makes long and slender tracks under the bark, which radiate from a primary, larger and vertical chamber (Fig. 235). The beetle (Fig. 245), is entirely black, or black with brown wing-covers; the head above is flat, concave towards the tip; the thorax



Fig. 245.—*Scolytus 4-spinosus*, Say.

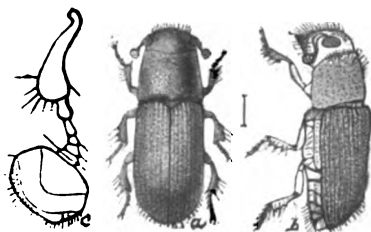


Fig. 246.—*Dendroctonus frontalis*, Zimm.—After Division of Entomology, U. S. Department of Agriculture.

is a little longer than wide, narrower in front; the wing-covers have about ten striæ, confused at the sides, but regular above, composed of small, deep, approximate punctures, the spaces between the striæ having a single row of minute, almost obsolete punctures. The male has the excavated venter armed with two long and two shorter spines, and the rim upon the ventral and posterior segments is also armed with a very stout, short and broad projection; all of which are absent in the female. The entire head is hidden by long and fox-colored hair, more dense in the male than in the female.

Both sexes bore into the tree, the male for food, the female for the purpose of laying eggs. In doing so they bore in a slanting upward direction, both in the trunk and branches. The entrance is usually made in the axil of a bud or leaf, which causes the twig to die, and the leaves to wither and drop. Mr. Bryant, in describing the actions of the female, says, that in depositing the eggs she confines herself to the trunk and larger limbs, placing her eggs on each side of a vertical chamber. Here she dies, and her remains may be found long after her progeny have commenced to make their cylindrical tunnels, at first transverse and diverging, but afterwards lengthwise along the bark, always crowding the widening burrows with their powdery excrement, which is of the same color as the bark. The full grown larva is soft, yellowish, and without traces of legs, with the head slightly darker with brown jaws. It remains torpid during the winter, transforming to a pupa towards the end of the following May. The pupa, also shown, is smooth and unarmed, not showing any sexual differences. The beetles issue through holes made direct from the sap-wood, and a badly infested tree looks as though it had been peppered with No. 8 shot.

A large number of other similar beetles are also destructive to our trees. A small hickory-bark beetle, (*Chramesus icoriae* Lec.), is not alone found in the food expressed by its specific name, but also in the buds of oak, which are greatly enlarged by the irritation produced by its presence.

Pine trees suffer greatly from insects belonging to the genera

Tomicus, *Dendroctonus*, *Hylastes*, and others; and such beetles have to be constantly fought in well regulated pine forests to prevent heavy losses. *Dendroctonus frontalis* is illustrated (Fig. 246), to show the form of such beetles; and a still larger one, very common in our pine forests, the *D. terebrans* Oliv., in Fig. 247.

There is still another beetle belonging to this family that deserves at least passing notice, as it may find its way to our

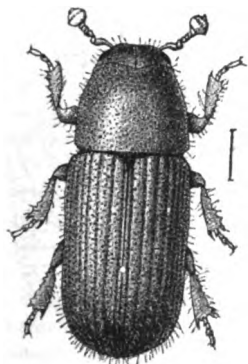


Fig. 247.—*Dendroctonus terebrans*. Oliv. After Division of Entomology, U. S. Department of Agriculture.



Fig. 248.—*Hylesinus trifolii*, Muell. After Division of Entomology, U. S. Department of Agriculture.

state in the future. It has the rather abnormal habit of making burrows in the roots of clover and allied plants, and it has become a very serious pest in the Eastern States into which it found its way from Europe. A large proportion of the two year old clover plants are destroyed by this insect which can be found in all stages in such snug quarters during the winter months. The clover-root Borer (*Hylesinus trifolii* Muell.), is illustrated in Fig. 248.

FAMILY ANTHRIBIDAE.

(Fungus beetles).

There is still another family of beetles closely related to the snout-beetles and bark-beetles. Some of them are found in large numbers upon dead toad-stools; others occur among the fungi causing certain diseases of the cereals and other plants; and still others are known to be elsewhere decidedly injurious to cultivated plants. To show how such beetles look the illustration of *Anthri-*

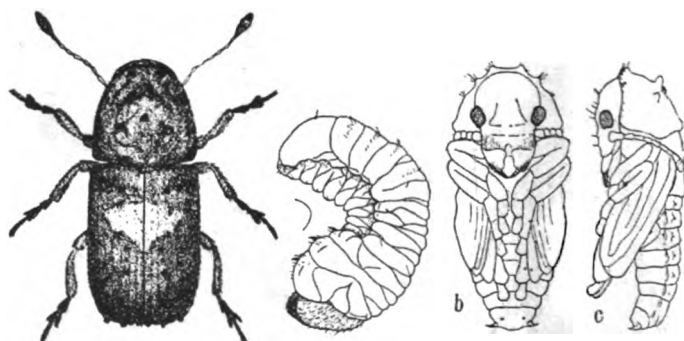


Fig. 249.—*Anthribus cornutus*, Say. After Marlatt.

bus cornutus Say (Fig. 249), has been reproduced from the First Annual Report of the Kansas Experiment Station. This insect was found in large numbers and in all stages associated in dead tamarix stems with the injurious apple-twig borer (*Amphicercus bicaudatus* Say) described before.

It will be seen from the pages of this report that the ORDER of COLEOPTERA contains a large number of injurious insects, and that it is worth while to inspect our fruit-producing plants with great care from time to time to detect them, to apply remedies as soon as possible, and not to wait until our enemies have multiplied to such an extent as to make it questionable whether we or the intruders are the masters of the situation.

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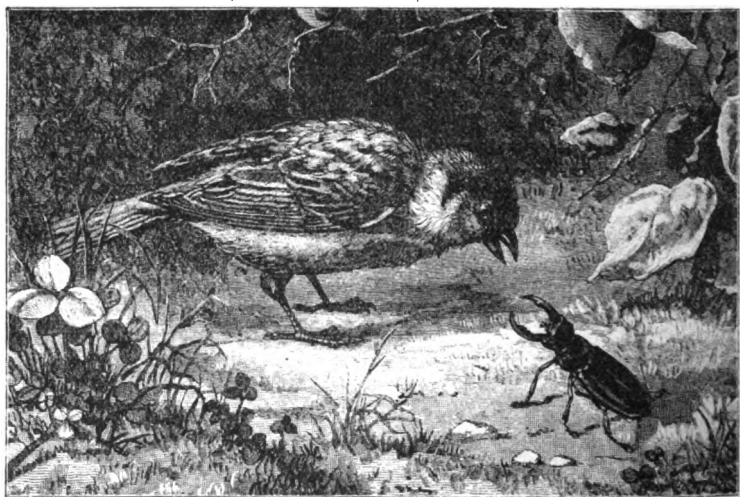
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"Look Out!"

PLATE I.

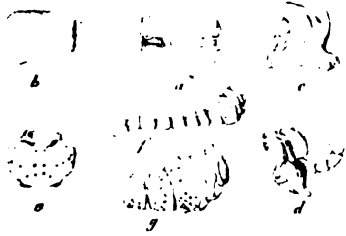


Fig. 181.—*Zopherus Haldemani* Sallé.
After Sturm.

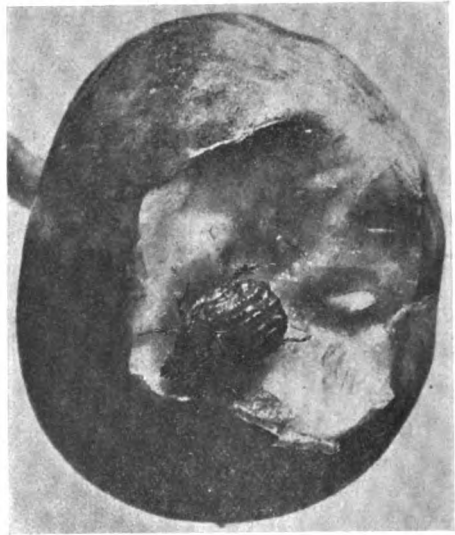


Fig. 108.—*Euphoria inda* in apple.

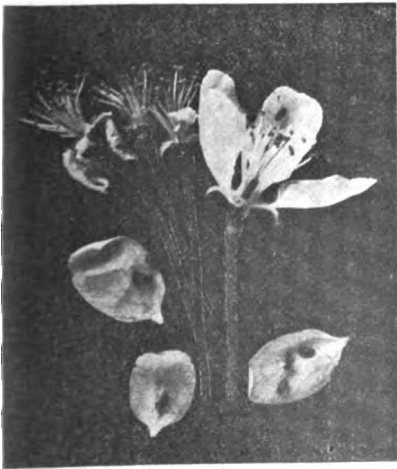


Fig. 48.—*Carpophilus brachypterus* Say,
in flowers of apple



Figs. 87 and 88.—A, *Dichelonychia elongata* Fab.;
B, *D. subvittata* Lec.; C, *Serica iricolor* Say;
D, *S. vespertina* Gyll.; E, *Hoplia modesta* Hald.

PLATE II

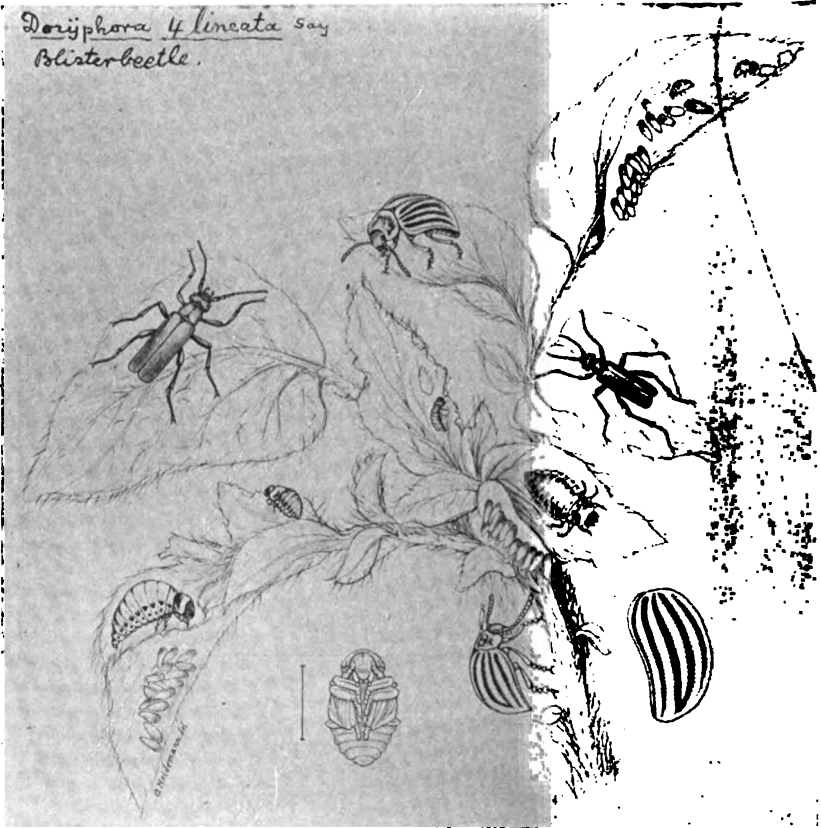


Fig. 151.—*Doryphora 10-lineata* Say., and Blister-beetles. Original.



Fig. 192.—*Anametis grisea* Horn.



Fig. 182.—*Boletotherus bifurcus* Fab.; male and female.

PLATE III.

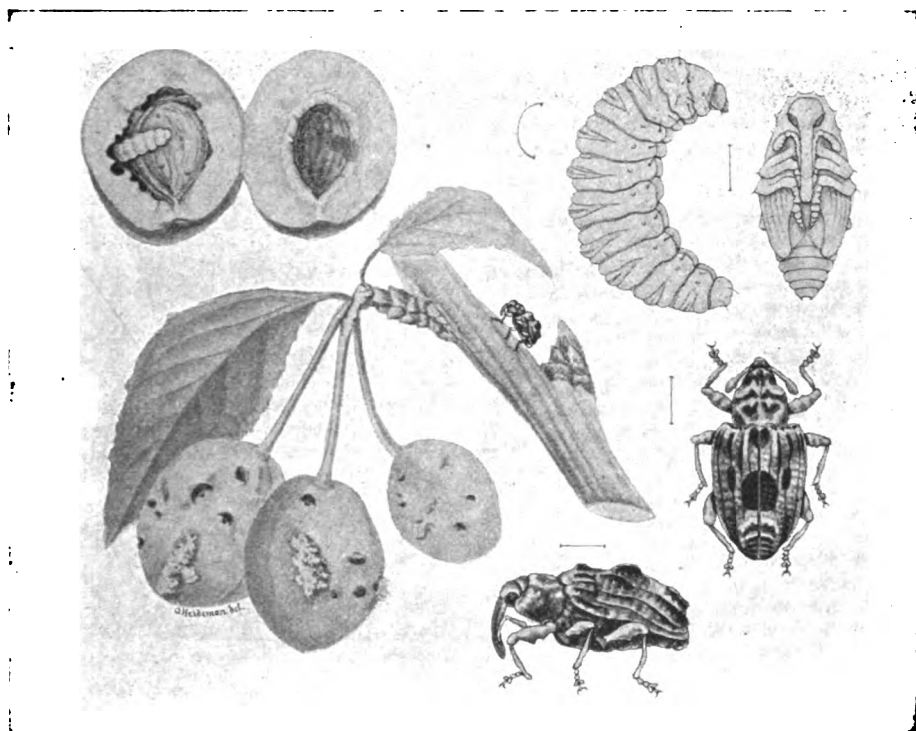


Fig. 213.—*Conotrachelus nenuphar* Hbst. Original.



Fig. 223.—*Tachygonus Lecontei* Gyll.
After Sturm.



Fig. 101.—*Cotalp lanigera* Linn. After Harris.

PLATE IV.

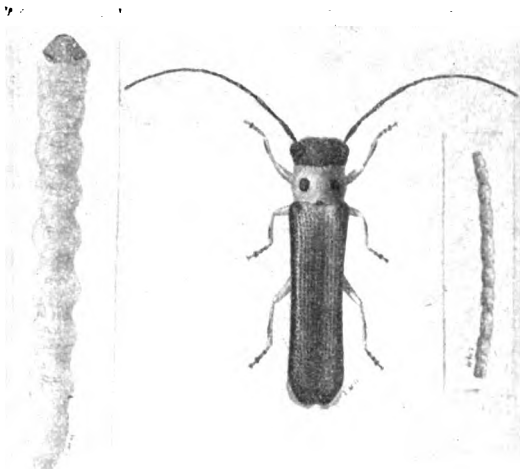


Fig. 136.—*Oberea bimaculata* Oliv.; adult, larva and castings. After Webster.



Fig. 125.—*Gaurotes cyanipennis* Say.



Fig. 114.—*Parandra brunnea* Fab.

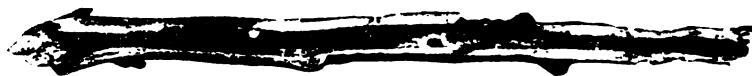


Fig. 136.—Burrow of *Oberea bimaculata* Oliv.

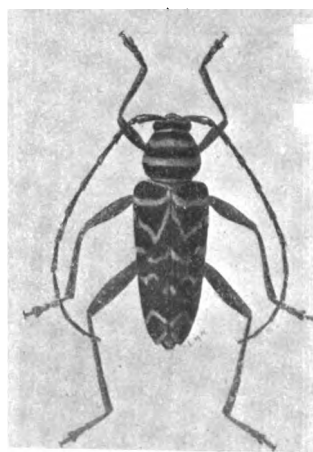


Fig. 122.—*Cyllene pictus* Drury. After Webster.

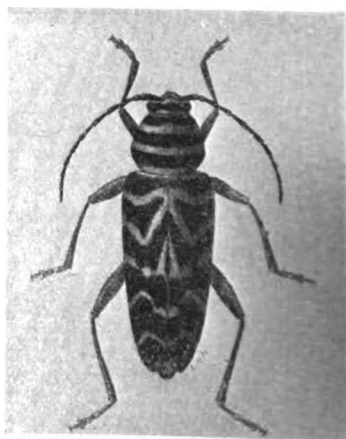


Fig. 123.—*Cyllene oblinia* Forst. After Websterr.

PLATE V.

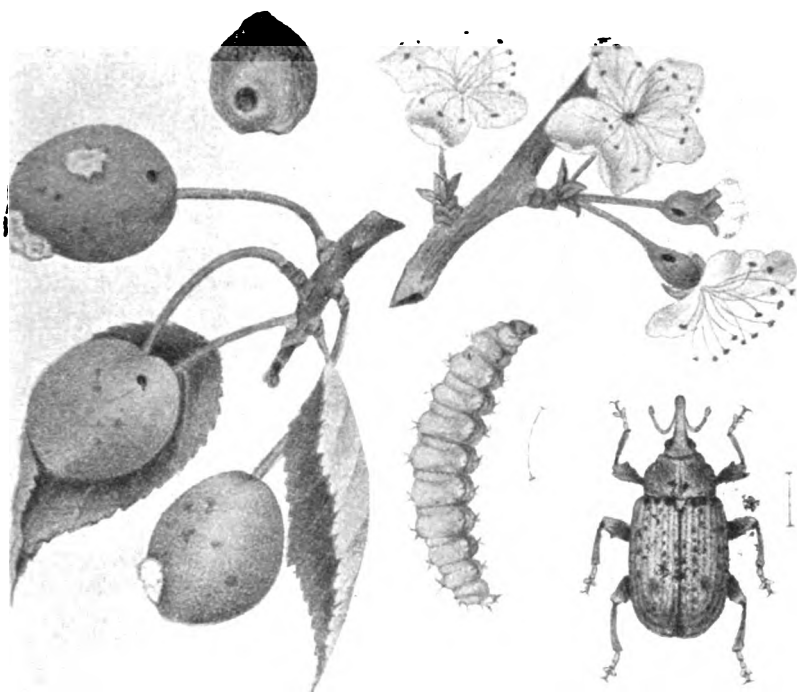


Fig. 207.—*Coccotorus scutellaris* Lec. Original.



Fig. 121. — *Tylonotus bimaculatus* Hald.

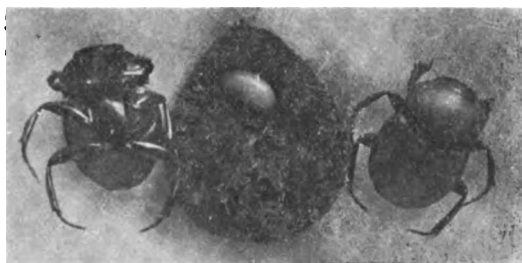


Fig. 81.—*Canthon laevis* Drury: adults, ball and egg.

PLATE VI.

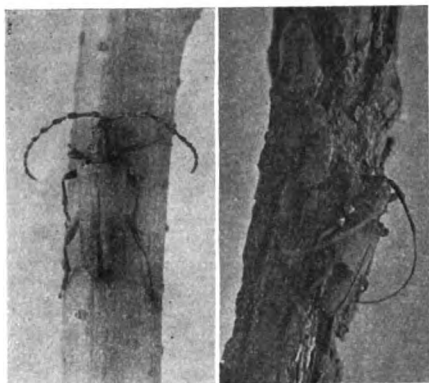


Fig. 124.—*Desmocerus palliatus* Forst.

Fig. 129.—*Goespulchra* Hald.



Fig. 196.—*Ithyercus noveboracensis* Forst., on bark and leaves of plum.



Fig. 113.—*Trichius affinis* Gory.



Fig. 116.—*Prionus* still in burrow.



Fig. 164. *Haltica ignita* Ill.; larva stage.

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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 67.

DAIRY DIVISION.

APRIL, 1900.

1. INVESTIGATION IN MILK PRODUCTION.
 2. FEEDING DAIRY COWS.
-

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

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UNIVERSITY OF MINNESOTA.

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The bulletins of this station are mailed free to all residents of the state who make application for them.

INVESTIGATION IN MILK PRODUCTION.

T. L. HÆCKER.

The results of the experiments reported in this bulletin are, in part, a continuation of those reported in Bulletin 35, issued from this station in the fall of 1894, and cover the work of the dairy herd for 1894, 1895, 1896, and the winter's work for 1895-96. The latter is considered separately because a more accurate account can be kept of the actual amount of feed consumed by each animal, and the chemical composition of the different feed stuffs used. While the primary object of keeping a complete record of the herd is to ascertain the cost of milk and butter production under conditions obtaining in the northwest, the winter's work was conducted to ascertain the amount of dry matter and digestible substances required by different cows to produce a given quantity of milk and butter fat.

Ever since the formation of the dairy herd in the fall of 1891, every milking from every cow has been weighed and tested separately by the Babcock test for per cent. fat. All the scales used in the dairy division have beams divided into pounds and decimals of a pound, they are provided with agate bearings and are regularly inspected by an official and are kept in perfect working condition.

The records are kept primarily by weeks, commencing with Monday morning and closing Sunday evening.

SYSTEM OF RECORDS.

UNIVERSITY OF MINNESOTA.

DIVISION OF DAIRY HUSBANDRY.

Weekly Milk Record from Jan. 6, 1896, to Jan. 12, 1896.

	Deckley.	Belle.	Countess.	Duchess.	Houston.	Ida.	Liggetta.	Lon.	Nora.	Olive.
6 A. M.	4.6	15.3	30.	11.6	18.	11.9	15.	15.	11.	15.5
6 P. M.	4.2	13.8	25.3	10.2	16.3	9.1	12.5	20.	11.1	13.
7 A. M.	4.1	15.5	29.	12.	17.9	12.1	14.5	14.1	11.	15.3
7 P. M.	3.7	13.1	24.6	9.5	15.5	10.1	13.5	7.7	9.6	13.7
8 A. M.	4.5	15.3	27.3	11.9	17.5	12.2	14.3	22.7	11.3	16.5
8 P. M.	3.7	13.4	23.7	10.	16.6	10.6	13.2	14.6	10.6	14.2
9 A. M.	4.3	15.5	28.2	11.5	14.7	12.2	14.7	10.9	11.	15.5
9 P. M.	3.4	14.3	25.2	10.	13.4	10.	13.3	20.5	10.0	13.3
10 A. M.	4.1	15.4	29.7	12.1	16.	11.5	15.2	15.6	11.2	16.7
10 P. M.	3.7	12.5	25.	10.1	12.9	9.3	13.2	14.7	10.	13.5
11 A. M.	4.	15.3	30.	12.	15.8	11.9	15.2	10.	11.7	16.2
11 P. M.	3.8	12.8	25.6	10.8	15.	10.5	13.1	19.6	9.8	13.6
12 A. M.	3.9	14.8	29.1	12.4	15.2	11.8	14.7	15.	11.	15.3
12 P. M.	3.7	12.8	25.	10.2	14.8	10.	12.8	14.6	10.	14.
	55.7	199.8	377.7	154.3	219.6	153.2	194.7	215.0	149.3	206.3

There are two four ounce sample bottles for every cow, one each for morning and evening milk. After each milking the samples are taken to the dairy laboratory and tested for per cent. fat.

UNIVERSITY OF MINNESOTA.

DIVISION OF DAIRY HUSBANDRY.

Test Record.

DATE—Jan. 6, 1896.	A. M.		P. M.	
	No. of Bottle.	Per Cent. Fat.	No. of Bottle.	Per Cent. Fat.
Beckley	45	5.2	46	5.9
Belle	278	8.5	7	4.2
Countess	210	2.2	85	2.8
Duchess	263	5.2	34	4.7
Houston	23	4.3	26	5.3
Ida	75	3.2	15	5.
Liggetta	53	3.3	230	3.1
Lon	37	2.1	31	3.
Nora	173	4.7	172	4.5
Olive	101	3.8	16	4.1

UNIVERSITY OF MINNESOTA.

DIVISION OF DAIRY HUSBANDRY.

Yearly Milk Record from Dec. 30, 1895, to Dec. 27, 1896.

1896.	Beckley.	Belle.	Countess.	Duchess.	Houston.	Ida.	Liggett.	Lou.	Nora.	Olive.
Dec. 30-Jan. 5	61.5	205.1	386.4	156.4	241.2	153.5	187.6	208.9	141.9	203.7
Jan. 6-12	55.7	199.8	377.7	154.3	219.8	153.2	194.7	215.0	149.3	206.8
13-19	55.0	198.4	373.3	162.7	217.5	147.0	192.9	216.1	150.5	196.3
20-26	52.2	194.1	356.1	147.8	205.7	146.1	184.1	217.1	145.9	19.9
27-Feb. 2	47.9	186.6	352.4	140.5	214.0	144.0	184.8	205.6	140.6	185.2
Feb. 3-9	48.8	185.2	313.1	137.3	220.9	129.8	191.9	191.4	136.5	179.3
10-16	44.6	175.4	327.4	131.8	218.8	135.6	183.0	189.6	130.4	167.5
17-23	42.4	167.8	316.8	127.6	213.7	133.0	182.8	191.6	131.2	161.6
24-Mch. 1	39.2	164.0	309.3	125.8	211.7	127.9	178.2	173.8	140.0	161.3
Mch 2-8	40.1	150.3	315.6	122.8	214.0	134.6	179.0	140.0	129.7	161.8
9-15	40.5	149.0	306.4	122.0	206.1	138.9	171.7	162.7	131.2	151.0
16-22	41.3	148.5	297.5	117.7	211.5	141.4	175.3	175.7	137.0	137.0
23-29	41.6	145.7	299.8	120.3	207.0	142.7	164.6	174.4	137.1	147.6
30-Apr. 5	42.1	138.5	283.8	120.6	210.4	140.2	146.8	170.6	126.9	144.3

At the close of the week the milk sheet is taken to the dairy office and footings made of pounds of milk given by each cow and the amount added to a yearly milk sheet, which is placed on the desk of the chief of the division, accompanied by the test blanks, for inspection, every Monday morning, after which the data is recorded in the milk record.

MILK RECORD.

1896	DUCHESS.						HOUSTON.					
	A. M.			P. M.			A. M.			P. M.		
Jan.	Lbs. Milk	Per ct. Fat	Total Fat	Lbs. Milk	Per ct. Fat	Total Fat	Lbs. Milk	Per ct. Fat	Total Fat	Lbs. Milk	Per ct. Fat	Total Fat
1	11.9	4.4	.52	10.5	3.0	.32	18.0	4.0	.72	16.0	4.7	.75
2	12.0	4.9	.59	10.3	4.4	.45	18.2	4.2	.76	16.0	5.4	.86
3	12.0	5.0	.60	10.3	5.3	.55	18.2	4.3	.80	16.4	5.0	.82
4	12.0	4.9	.59	10.3	5.0	.52	18.2	4.1	.74	16.0	4.4	.70
5	12.0	4.9	.59	10.1	5.1	.52	17.8	4.7	.84	16.6	5.3	.84
6	11.6	5.2	.60	10.5	4.7	.48	18.0	4.3	.77	16.3	5.3	.86
7	12.0	4.6	.55	9.5	4.8	.46	17.9	4.5	.81	15.5	5.3	.82
8	11.9	4.6	.55	10.0	3.6	.36	17.5	3.6	.63	16.6	5.6	.93
9	11.5	4.4	.53	10.0	4.9	.48	14.7	4.5	.66	13.4	5.2	.70
10	12.1	4.8	.58	10.1	4.3	.46	16.0	5.1	.82	12.9	3.4	.70
11	12.0	4.8	.58	10.8	4.7	.51	15.9	5.2	.82	15.0	5.6	.94
12	12.4	4.9	.61	10.2	4.6	.47	15.2	5.2	.79	14.8	4.9	.73

A chemical analysis is made of all feed stuffs used. All food is weighed out to each cow at every feeding period. A daily report is made by the dairy stock foreman as to the condition and conduct of all the animals in the division.

UNIVERSITY OF MINNESOTA.

DIVISION OF DAIRY HUSBANDRY.

Daily Report of Stock Foreman.

All the stock were weighed this morning.

Fly T. calved to-day. Time, 9 months, 17 days. Bull calf, large and strong. Cow passed her afterbirth and is seemingly in good condition for work.

Dell 2 was bred to the Jersey bull O. W. Pogis.

Euroma is beginning to make udder. She is being treated for abortion.

Bettie, Alzanka and Yellow Belle are being dried off.

St. Anthony Park, Minn., November 7, 1898.

Signed, A. J. McGUIRE.

A report is also made by the stock foreman stating the amount and kind of feed given to each animal.

UNIVERSITY OF MINNESOTA.

DIVISION OF DAIRY HUSBANDRY.

Feed Record of Cows from Jan. 6, 1896, to Jan. 12, 1896.

ROUGHAGE.	GRAIN MIXTURE.
Hay, 8	Bran, 600.
Fodder Corn,	Barley, 400.
Ensilage, . . . 20	Corn,
Roots,	Oats, 300.
Grain, 14	Oil Meal, . . . 100.

DAIRY HERD	Hay	Ensilage	Grain
Beckley 2	8.0	20.0	14.0
Belle	8.5	21.5	15.0
Countess	12.0	30.0	21.0
Duchess	7.5	18.5	13.0
Houston	8.0	20.0	14.0
Ida	8.5	21.5	15.0
Liggetta	9.0	23.0	16.0
Lou	9.0	23.0	16.0
Nora	8.0	20.0	14.0
Olive	7.0	17.0	12.0

The data contained in the above report is recorded in the feed record.

FEEDING RECORD.

1896	DUCHESS						HOUSTON					
Jan.	Bran	Barley	Corn	Oil Meal	Hay	Ensil- age	Bran	Barley	Corn	Oil Meal	Hay	Ensil- age
1	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
2	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
3	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
4	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
5	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
6	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
7	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
8	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
9	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0
10	5.58	3.74	2.76	.92	7.5	18.5	6.0	4.0	3.0	1.0	8.0	20.0

From the data in these two records the calculations for the dairy record are made in weekly periods, giving the total amount of roughage, succulent feed and grain consumed during the week; the amount and kind of concentrates which constituted the daily grain ration; the dry matter in the daily ration, the cost of the feed at local market quotations; the pounds of milk, average per cent. fat, pounds of butter fat and butter; cost of a hundred pounds of milk, a pound of butter fat and a pound of butter; and the dry matter required for a pound of butter fat and a pound of butter.

INVESTIGATION IN MILK PRODUCTION.

UNIVERSITY OF MINNESOTA—DAIRY DIVISION.

HOUSTON.

Date, 1896.	FRD.				DAILY GRAIN RATION.				D. M.	N. R.	Cost of Feed.	Pounds of Milk.	Per Cent Fat	Pounds of Fat.	Pounds of Butter.	Cost of 100 lbs. of Milk.	Cost of 1 lb. of Butter Fat.	Cost of 1 lb. of Butter.	D. Butter Fat.	D. M. for 1 lb. Butter.
	Hay.	Grain.	Busilage.		Brn.	Barley.	Oats.	Oil Meal.												
Dec. 30 to																				
Jan. 5.....	56.	98.	140.	.....	6.	4.	3.	1.	32.56	.....	5011	241.2	4.63	11.14	18.00	2160	0.468	0.401	14.18	12.15
Jan. 6-12.....	52.	91.	130.	.....	6.	4.	3.	1.	32.56	.....	4399	215.6	4.95	10.86	16.67	2204	0.446	0.382	13.50	11.51
Jan. 13-19.....	56.	98.	140.	.....	6.	4.	3.	1.	32.56	.....	5211	217.5	4.63	10.91	11.80	2396	0.515	0.442	15.62	13.57
Jan. 20-26.....	52.5	91.	129.5	.....	5.58	3.74	2.76	.92	20.81	.....	4844	208.7	5.13	10.56	12.32	2355	0.459	0.393	13.79	11.82
Jan. 27 to																				
Feb. 2.....	52.5	91.	129.5	.....	5.58	3.74	2.76	.92	21.59	.....	5038	214.0	4.70	10.14	11.83	2354	0.497	0.426	14.90	12.78
Feb. 3-9.....	48.	81.	119.	.....	5.16	3.48	2.52	.81	20.83	.....	4334	220.9	5.24	11.58	13.51	2188	0.417	0.318	12.59	10.79
Feb. 10-16.....	52.5	91.	129.5	.....	5.18	3.74	2.76	.92	22.51	.....	5233	218.2	4.88	10.88	12.46	2392	0.490	0.420	14.75	12.65
Feb. 17-23.....	52.5	91.	129.5	.....	5.58	3.74	2.76	.92	22.51	.....	5233	218.7	5.04	10.77	12.57	2449	0.486	0.416	14.63	12.54
Feb. 24 to																				
Mch. 1.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	211.7	5.19	10.99	12.82	2660	0.512	0.439	15.41	13.21
Mch. 2-8.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	214.0	5.38	11.41	13.81	2631	0.494	0.423	14.85	12.73
Mch. 9-15.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	206.1	4.74	9.77	11.40	2732	0.576	0.494	17.35	14.98
Mch. 16-22.....	54.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	211.5	4.89	10.86	12.09	2662	0.544	0.466	16.35	14.01
Mch. 23-29.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	207.0	5.03	10.32	12.16	2720	0.540	0.463	16.26	13.93
Mch. 30 to																				
Apr. 5.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	210.4	5.16	10.91	12.73	2676	0.516	0.442	15.53	13.91
Apr. 6-12.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	208.2	5.51	11.48	13.39	2705	0.491	0.421	14.78	12.65
Apr. 13-19.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	202.4	5.42	10.96	12.79	2782	0.514	0.443	15.48	13.24
Apr. 20-26.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	201.5	5.14	10.37	12.10	2794	0.543	0.465	16.33	14.00
Apr. 27 to																				
May 3.....	56.	98.	140.	.....	6.	4.	3.	1.	24.20	.....	5631	193.9	5.58	10.82	12.62	2904	0.520	0.446	15.66	13.42
May 4-10.....	24.	41.	30.	.....	3.2	1.43	1.07	.36	.....	.....	4306	184.7	5.53	10.32	11.92	2831	0.431	0.361	.....	.....

UNIVERSITY OF MINNESOTA—DAIRY DIVISION—Continued.

HOUSTON.

Date. 1896.	FEED.		DAILY GRAIN RATION.				D. M.	N. R.	Cost of Feed	Pounds of Milk.	Per Cent. Fat.	Pounds of Fat.	Pounds of Butter.	Cost of 100 lbs. of Milk.	Cost of 1 lb. of Butter Fat.	Cost of 1 lb. of Butter.	D. M. for 1 lb. Butter Fat.	D. M. for 1 lb. Butter.
	Hay.	Grain.	Ensilage.	Bran.	Barley.	Oats.												
May 11-17.....	35.		Past're	2.14	1.43	1.07	.36		3.481 190.3	5.06	9.63	11.24	1829	0.862	0.810			
May 18-24.....	28.		"	1.72	1.16	.84	.28		3.219 186.3	4.73	8.82	10.29	1728	0.868	0.813			
May 25-31.....	21.		"	1.29	.87	.63	.21		2.967 183.6	6.23	9.91	11.21	1611	0.808	0.864			
June 1-7.....	21.		"	1.29	.87	.63	.21		3.447 183.7	4.76	8.74	10.20	1875	0.894	0.838			
June 8-14.....	14.		"	.86	.58	.42	.14		3.184 191.4	4.49	8.60	10.03	1663	0.870	0.817			
June 15-21.....	14.		"	.86	.58	.42	.14		3.184 177.4	4.66	8.09	9.44	1796	0.884	0.837			
June 22-28.....	14.		"	.86	.58	.42	.14		3.184 194.1	4.87	9.45	11.03	1640	0.887	0.889			
June 29 to July 5.....	14.		"	.86	.58	.42	.14		3.184 190.5	4.53	8.63	10.07	1671	0.869	0.816			
July 6-12.....	14.		"	.86	.58	.42	.14		3.184 181.9	4.78	8.98	10.13	1764	0.867	0.814			
July 13-19.....	14.		"	.86	.58	.42	.14		3.184 176.3	6.05	8.91	10.40	1808	0.857	0.804			
July 20-26.....	14.		"	.86	.58	.42	.14		3.184 185.3	4.58	8.48	9.89	1718	0.876	0.822			
July 27 to Aug. 2.....	21.		"	1.29	.87	.63	.21		3.447 174.2	4.89	8.52	9.94	1979	0.405	0.847			
Aug. 3-9.....	28.		"	1.72	1.16	.84	.28		3.703 170.5	4.73	8.16	9.52	2175	0.455	0.890			
Aug. 10-16.....	28.		"	1.72	1.16	.84	.28		3.703 168.1	5.23	8.00	10.88	2208	0.417	0.857			
Aug. 17-23.....	28.		"	1.72	1.16	.84	.28		3.703 169.1	4.23	8.42	9.82	2198	0.440	0.878			
Aug. 24-30.....	28.		"	1.72	1.16	.84	.28		3.703 166.9	5.24	8.70	10.16	2286	0.426	0.865			
Aug. 31 to Sept. 6.....	70.		Fodder	4.28	2.88	2.14	.72		3.703 148.8	5.97	7.99	9.32	2493	0.464	0.998			
Sept. 7-13.....	98.		"	1.72	1.16	.84	.28		3.129 148.6	5.09	7.58	8.84	2103	0.413	0.854			
Sept. 14-20.....	98.		"	1.72	1.16	.84	.28		3.129 150.5	5.51	8.30	9.70	2079	0.377	0.823			
Sept. 21-27.....	105.		"	2.14	1.43	1.07	.36		3.461 146.8	6.91	8.68	10.13	2358	0.399	0.842			
Sept. 28 to Oct. 4.....	63.		Roots	2.14	1.43	1.07	.36		2.657 139.9	6.11	8.55	9.98	1899	0.311	0.268			
Oct. 5-11.....	56.		63.	3.86	2.59	1.91	.64		3.011 111.8	9.92	7.03	8.20	2705	0.428	0.859			
Oct. 12-18.....	56.		63.	3.86	2.59	1.91	.64		3.011 19.4	5.15	1.00	1.17	1.532	3.011	2574			

During the time the cows are in pasture, each is charged in proportion to the amount of feed consumed during the winter months. A cow that takes fourteen pounds of grain per day during the winter is charged 25 cents per week for pasture and those that take more or less than this amount are charged proportionately more or less per week.

HERD RECORD FOR 1894.

The Herd:—The following table gives a list of the cows in the herd at the beginning of the year, age, breeding, date of calving, when placed in the herd, when removed from the herd and cause of removal:

TABLE XVII.—List of Cows in the Dairy Herd.

Name	Age	Breed.	Date of Calving	Joined the Herd	Left Herd	Cause.
Allie	4	Native	Apr. 1 '94	Apr. 1 '94	.....	.....
Beckley	9	Grade Jersey	Jun. 12 '94	Nov. 1 '91	Oct. 8 '94	For Beef
Bess	10	Holstein	Feb. 22 '94	Dec. 18 '91	Nov. 17 '94	Tuberculosis
Bettie	9	Guernsey	Aug. — '93	Nov. 1 '91	.....	.....
Clara	8	Grade Jersey	May 27 '93	Nov. 1 '91	July 8 '94	For Beef
Daisy	2	Grade Guernsey	Nov. 19 '93	Nov. 20 '93	.....	.....
Dido	11	Grade Shorthorn	Feb. 24 '93	Feb. 27 '93	Apr. 2 '94	Tuberculosis.
Dora	12	Jersey	Mch. 9 '93	Dec. 18 '91	.....	.....
Ethel	4	Grade Shorthorn	Apr. 1 '94	Apr. 1 '94	.....	.....
Fancy	8	Polled Angus	May 8 '93	May 8 '93	May 5 '94	Tuberculosis.
Gertie	5	Grade Jersey	Oct. 2 '93	Nov. 1 '91	Sep. 17 '94	For family cow.
Houston	10	Jersey-Guernsey	Nov. 5 '93	Nov. 1 '91	.....	.....
Jennie	6	Holstein	Oct. 28 '94	Dec. 18 '91	Nov. 5 '94	For family cow.
Mollie	2	Grade Shorthorn	Nov. 20 '93	Nov. 20 '93	June 6 '94	Tuberculosis.
Nora	4	Jersey-Guernsey	.....	Nov. 24 '92	.....	.....
Olive	10	Grade Guernsey	Feb. 5 '94	Nov. 30 '91	.....	.....
Patsy	7	Grade Jersey	Apr. 2 '94	Nov. 1 '91	.....	.....
Pride	11	Jersey	Sept. 5 '94	Nov. 1 '91	.....	.....
Reddy	10	Grade Guernsey	Nov. 28 '93	Nov. 20 '91	Oct. 10 '94	For beef.
Rose	11	Grade Shorthorn	Apr. 7 '93	Nov. 17 '91	Oct. 1 '94	Tuberculosis.
Rossie	6	Grade Jersey	.....	Nov. 1 '91	.....	.....
Roxey	9	Grade Jersey	Aug. 10 '93	Nov. 1 '91	Sep. 19 '94	For family cow.
Sully	10	Grade Shorthorn	.....	Nov. 17 '91	May 5 '94	Tuberculosis.
Sweet B	10	Guernsey	Oct. 28 '93	Nov. 1 '91	.....	.....
Topay	8	Grade Holstein	Nov. 9 '93	Dec. 18 '91	.....	.....
Tricksey	10	Guernsey	Dec. 25 '93	Nov. 1 '91	Mch.— '94	Tuberculosis.

The foregoing table includes all the animals whose records for 1893 appeared in Bulletin 35 except Annie, that was not the property of the University, and was returned to her owner. Tricksey calved on the 25th of Dec. 1893 had an attack of milk fever, from which she recovered, but soon after began to fail, and in March died. A post mortem

showed that she was badly affected with tuberculosis. She had been dry about ten days, weighed 1,100 pounds twenty days before calving, and was at that time apparently in good health. Her average weight for December the year previous was 1,095, showing that prior to calving, to all appearance, she was in normal condition.

On the 20th of April the whole herd was tested with tuberculin. The cows reacting to this test were Dido, Fancy, Houston, Rose, Sullie, Mollie—a daughter of Sully—Houston 2d and a heifer calf from Mollie. All these were taken out of the dairy herd except Houston, that failed to react on the second trial made on the 29th of June. The last of October the whole herd was again tested for tuberculosis, when Bess and two other beef cows, that had been in the herd from the time it was formed but never listed with the dairy cows, were found diseased.

Gertie, Jennie and Roxie were sold for family cows. Beckley, Clara, Reddie and Rossie were sold for beef.

The following table gives a list of cows that remained in the herd during the year, their breeding, days in milk, and pounds of milk and butter fat yielded:

TABLE XVIII.—Individual Yields of Milk and Butter Fat, 1894.

NAME.	Breed.	Days in Milk.	Lbs. of Milk.	Lbs. of Butter Fat.
Allie.....	Native	275	3871.7	161.35
Bettie.....	Guernsey	365	3617.1	218.17
Dora.....	Jersey	309	5153.8	277.75
Ethel.....	Gr. Shorthorn	247	4146.3	172.48
Houston.....	Jersey-Guer.	291	5952.0	305.46
Nora.....	Jersey-Guer.	365	3912.8	199.43
Patay.....	Gr. Jersey	282	5499.0	233.92
Pride.....	Jersey	292	4404.0	222.35
Sweet Briar.....	Guernsey	284	4744.9	232.12
Topsy.....	Gr. Holstein	308	7769.1	304.54
Average.....		306	4907.0	232.75

The yield in milk and butter fat was exceedingly low as compared with the two years previous. In 1892 the average yield of milk per cow was 5,763 pounds, and 264 pounds

of butter fat. In 1893 it was on an average 6,921 pounds of milk and 300 pounds of butter fat. The light yield for 1894 was due to frequent and unusual disturbances in the herd and a rapid shrinkage in the flow of milk after the middle of June because of poor pasturage. There was no special effort made to keep up the flow during the summer months and the results obtained are such as may reasonably be expected on a farm when little attention is given to the herd during the summer.

Allie and Ethel were from the range. They were intended for beef but after being fed a short time gave indications of being in calf and were therefore turned over to the Dairy Division. Bettie and Nora aborted and Pride seemed out of condition during the year. Subsequently a post mortem showed that she had swallowed a number of wire nails. Some had gone through the stomach and produced an abscess which was the cause of her death. There have been several such cases in the dairy herd since it was established. The cow Beauty, whose record appears in the annual report of the experiment station for the year 1893 had in her stomach the bowl of a table spoon, a pebble three quarters of an inch in diameter, two smaller ones, a horse shoe nail, the upper half of an old fashioned ten penny fence nail and another piece of old rusty nail. In the Journal of Comparative Medicines and Veterinary Archives on page 159 is a report of a case where a cow was out of condition for a long time and finally died. A post mortem was made and there was found in her rumen "a curry comb, in two parts; four pounds of nails; five pounds of spikes; a dress skirt; parts of several boots, shoes and rubbers; a coil of bailing wire; twenty-four balls of hair, the largest the size of an orange, the smallest the size of a walnut; a cogwheel one and a half inches in diameter, pieces of wool and much clay." A stomach encumbered with such foreign substances is not likely to do efficient work, and data obtained from such a source is apt to be misleading.

The following table gives a list of the dairy cows in the herd a portion of the year, excepting the cows Ethel and Allie:

NAME.	Breed.	Days in Milk.	Lbs. of Milk.	Lbs. Butter Pat.
Beckley.....	Gr. Jersey	281	2954.0	181.68
Bess.....	Holstein	251	7445.8	252.90
Daisy.....	Gr. Guernsey	804	3200.7	166.27
Reddie.....	Gr. Guernsey	272	4466.0	215.41
Rossie.....	Gr. Jersey	251	4257.2	171.07

Bess was removed because of tuberculosis, Reddie, Rossie and Beckley because they were quite fat and were getting less useful in the herd.

Food and Feeding:—The food used from the beginning of the year until the cows were turned out to pasture was, for roughage, timothy, prairie hay and ensilage, and for grain, bran, barley, dent corn and oil meal. The barley and corn were ground and mixed with bran in the proportion of fifty pounds of corn and fifty pounds of barley with one hundred pounds of oil meal. When the cows were fed in stall the ration was adjusted as nearly as possible to the needs of each animal and no changes made except such as were necessary in an experiment comparing timothy with prairie hay. The wild hay is what is generally known as upland prairie, early cut and nicely cured. The timothy was good quality, stems quite fine, cut in the bloom and nicely cured.

The following table gives the dry matter and digestible nutrients contained in a pound of the different food-stuffs given the herd from the first Monday in January to the first Monday in May when it was turned to pasture:

FOOD	Lbs.	D. M.	DIGESTIBLE.		
			Pro.	C-H	Fat.
Bran.....	1	.8960	.1153	.8824	.0856
Barley.....	1	.8822	.0944	.5974	.02
Corn.....	1	.8927	.1008	.6628	.04
Oil Meal.....	1	.8989	.2750	.3788	.07
Ensilage.....	1	.28	.0126	.1555	.0081
Prairie Hay.....	1	.8915	.0348	.4316	.0141
Timothy.....	1	.8768	.0318	.4509	.018

The following ration was fed from the 1st to the 16th of January, the amount of feed given depending upon the capacity of each animal, except as a cow was nearing the time of calving the feed would be considerably lessened and in some cases the grain discontinued.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost. Cents.
			Pro.	C-H	Fat.	
Bran.....	5.50	4.93	.63	2.10	.19	3.02
Barley	2.53	2.23	.24	1.51	.05	1.77
Corn.....	2.53	2.25	.25	1.68	.10	1.77
Oil Meal.....	1.43	1.28	.89	.54	.10	1.88
Prairie Hay.....	6.	5.85	.21	2.59	.08	.98
Ensilage.....	28.	7.84	.85	4.35	.23	2.80
		23.88	2.07	12.77	.75	12.20
N. R.						.1 6.9

To give the cows fixed rations as to quantity would make most of the work of little, if any, value. Farmers who pay any attention to feeding give each animal as much as it seems able to digest and assimilate. We do the same, but weigh and analyze the food to secure accurate data. If the quantity of feed each animal receives were arbitrarily fixed, no reliable data could be obtained showing the relation between conformation and cost of production, and it is for this reason that the members of the herd have about what they want as to quantity, so they can make such disposition of it as the heredity and temperament of each animal may determine.

The following table shows the amount of grain, hay and ensilage given to each member of the herd during the second week in January, the grain being a mixture composed of 100 pounds of bran, 50 of barley, 50 of corn and 25 of oil meal:

NAME.		Grain	Hay	Ensil- age
Beckley.....	Grade Jersey	8	6	24
Betty.....	Guernsey	8	6	24
Bess.....	Holstein	8	6	24
Clara.....	Gr. Jersey	8	6	24
Daisy.....	Gr. Guernsey	8	6	24
Dido.....	Gr. Shorthorn	8	4	24
Dora.....	Jersey	10	6	24
Fancy.....	Polled Angus	8	6	24
Gertie.....	Grade Jersey	12	6	28
Houston.....	Jersey-Guernsey	12	6	28
Jenny.....	Holstein	12	6	28
Mollie.....	Gr. Shorthorn	10	6	24
Nora.....	Jersey-Guernsey	8	6	24
Olive.....	Gr. Guernsey	8	6	24
Patsy.....	Gr. Jersey	6	6	20
Pride.....	Jersey	10	6	24
Reddy.....	Gr. Guernsey	12	4	20
Rose.....	Gr. Shorthorn	12	6	28
Rossie.....	Gr. Jersey	8	6	24
Roxy.....	Gr. Jersey	12	4	28
Sully.....	Gr. Shorthorn	12	6	28
Sweet B.....	Guernsey	12	6	28
Topay.....	Gr. Holstein	12	6	28

On the 16th of January the herd was divided into four groups for the purpose of comparing timothy with prairie hay. Two of the groups received grain and timothy and grain and prairie hay in alternate periods. The other two groups received grain and ensilage with timothy and prairie hay in alternation.

TABLE XIX.—Nutrients in Ration Composed of Grain and Timothy.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost, Cents.
			Pro.	C-H	Fat.	
Bran.....	6.17	5.53	.71	2.36	.22	3.39
Barley.....	3.08	2.72	.29	1.84	.06	2.15
Corn.....	3.08	2.72	.31	2.04	.09	2.15
Oil Meal.....	1.65	1.50	.45	.52	.12	2.14
Timothy.....	14.	12.28	.44	6.32	.25	3.92
		24.75	2.20	18.08	.74	13.75

TABLE XX.—Nutrients in Ration when Composed of Grain and Prairie Hay.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost. Cents.
			Pro.	C-H	Fat.	
Bran	6.17	5.53	.71	2.36	.22	3.89
Barley	8.08	2.72	.29	1.84	.06	2.15
Corn	8.08	2.72	.31	2.04	.09	2.15
Oil Meal	1.65	1.50	.45	.52	.12	2.14
Prairie Hay	14.	12.48	.33	5.72	.20	2.24
		24.97	2.09	12.48	.69	12.07

TABLE XXI.—Nutrients in ration Composed of Grain, Ensilage and Timothy.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost. Cents.
			Pro.	C-H	Fat.	
Bran	5.29	4.74	.61	2.02	.19	2.91
Barley	2.64	2.33	.25	1.58	.05	1.84
Corn	2.64	2.33	.27	1.75	.08	1.84
Linseed Meal	1.41	1.28	.38	.45	.10	1.83
Timothy	11.00	9.64	.35	4.98	.20	3.08
Ensilage	10.00	2.80	.11	1.82	.07	1.00
	32.98	23.12	1.97	12.08	.69	12.50

TABLE XXII.—Nutrients in Ration Composed of Grain, Prairie Hay and Ensilage.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost. Cents.
			Pro.	C-H	Fat.	
Bran	5.29	4.74	.61	2.02	.19	2.91
Barley	2.64	2.33	.25	1.58	.05	1.84
Corn	2.64	2.33	.27	1.75	.08	1.84
Linseed Meal	1.41	1.28	.38	.45	.10	1.83
Prairie Hay	11.00	9.81	.26	4.50	.14	1.76
Ensilage	10.00	2.80	.11	1.32	.07	1.00
	32.98	23.29	1.88	11.62	.63	11.18

During the time covered by this experiment it was necessary to give the same amount of feed to two of each of the groups and on that account the cows were given fixed rations, though the quantity of feed given to different cows

varied. The cows continued in full flow during the experiment and there was no noticeable change in yield caused by the different rations. There was no difficulty in making the changes from one ration to another, for the reason that their bulk, consistency and nutrient content were similar. It was intended to continue this experiment to the 28th of April, but on account of the mild weather, grass made an unusually early start, the cows became discontented in the barn and yard and the experiment was discontinued.

The herd was turned to pasture on the 5th day of May and received daily a grain feed composed of two pounds of ground corn and one of bran until the 11th of July, when 4 pounds of grain were given,—2 of bran and 2 of corn meal,—and as much green oats as they wanted. From the 18th of August, 6 to 10 pounds of hay and from 4 to 8 pounds of grain were given in addition to the little feed that could be picked up in the pasture at night and in the forenoon. From the middle of July the cows spent little of the time during the hot days in the pasture. The lane, gate and the door to the covered runways were kept open so they could come up at any time and occupy their stalls. The feed given during the summer and early fall was as follows:

July 11th to August 13th, hay 6 to 10 pounds, grain 4 to 8 pounds; August 14th to October 8th, cornfodder 8 to 10 pounds, grain 6 to 10 pounds; October 9th to October 28th, hay 10 to 16 pounds, grain 8 to 14 pounds. From the 29th of October to the 5th of November the cows were changed to a grain ration composed of ground wheat only. The wheat was ground quite coarse. For roughage they had timothy hay. The feeding was not judiciously done. The feeder, being new at the business, did not realize that a pound more or less in a ration might destroy the value of data obtained in an experiment. The cows were very fond of the ground wheat and by too rapidly increasing the grain several of them lost their relish for it the first part of the first week. The quantity of feed given during the two weeks appears in the following table:

TABLE XXIII.—Giving Pounds of Wheat and Timothy Fed to Each Cow.

NAME.	Nov. 5-11		Nov. 12-18	
	Ground Wheat, Lbs.	Timothy Lbs.	Ground Wheat, Lbs.	Timothy Lbs.
Allie.....	9	14	9	14
Beckley.....	8	11	8	12
Bettie.....	8	12	8	12
Dora.....	9	13	10	13
Ethel.....	8	12	7	12
Houston.....	10	13	9	13
Lou.....	10	16	8	16
Lydia.....	11	16	11	18
Nora.....	8	12	7	13
Olive.....	6	14	10	14
Patsy.....	8	13	10	13
Pride.....	8	13	10	13
Quidee.....	10	14	8	14
Sweet B.....	8	10	10	12
Topsy.....	12	18	12	18
Tricksey.....	8	11	10	12

From the 13th to the 18th they took all the wheat and seemingly were becoming accustomed to it, and it would have been continued had not the feed been too expensive.

On the 19th of November, an experiment comparing a ration composed chiefly of wheat with a standard ration was commenced. The two were composed of the following mixtures:

STANDARD RATION.

Bran 6 pounds.
Barley 4 pounds.
Corn 3 pounds,
Oil meal 1 pound.

WHEAT RATION.

Bran 6 pounds,
Wheat 7 pounds.
Oil Meal 1 pound.

The herd was divided into two groups and the time into four periods of two weeks each, with a week intervening for preliminary feeding. The last period ended the 30th of December.

All the cows were in fine working condition during the trial and no abnormal increase or shrinkage in milk took place.

TABLE XXIV.—Weight of Cows, Average for Months and Year. 1894.

NAME.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
Allie.....	959	984	1020	921	973	1014	981	995	997	1014	1087	1161	1016
Becky.....	1209	1154	930	1064	976	1029	1024	1000	976	919	.....	.....	1006
Bess.....	819	850	875	824	968	1015	1083	1074	1068	1071	.....	.....	1041
Bettie.....	724	712	709	893	892	916	844	835	809	782	823	849	849
Daisy.....	898	907	899	705	746	779	773	774	755	727	.....	.....	740
Dora.....	.....	.....	.....	825	784	795	823	838	809	817	850	872	843
Ethel.....	.....	.....	.....	969	964	1000	1018	1040	1011	1018	1058	1121	1022
Houston.....	928	871	874	854	814	883	918	923	972	970	906	906	902
Nora.....	846	842	873	881	906	902	884	885	829	813	814	856	861
Patsy.....	985	967	946	789	819	883	951	933	926	925	1002	1029	930
Pride.....	768	759	753	787	776	819	820	834	750	710	780	776	778
Reddie.....	967	937	935	943	960	1004	1027	1024	1050	914	.....	.....	976
Rossie.....	932	937	953	989	980	1043	1048	1038	1135	934	.....	.....	982
Sweet Briar.....	1044	1042	1046	1043	1051	1104	1109	1105	1121	1121	1116	1058	1081
Topay.....	1028	1026	1011	996	1075	1179	1231	1285	1290	1202	1143	1178	1138
Average.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	951

TABLE XXV.—Milk Record Monthly and Total for each Cow, 1894.

NAME.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Allie.....	240.8	206.2	221.7	542.4	647.6	607.8	439.6	467.1	404.0	364.5	259.8	139.4	3871.7
Becky.....	266.7	175.8	1151.2	769.9	1088.9	1079.0	869.8	848.2	732.5	736.0	299.7	314.8	2954.0
Bess.....	266.7	238.1	275.6	282.6	330.7	289.1	405.9	373.3	286.6	279.9	299.7	314.8	3643.0
Daisy.....	266.8	69.8	367.0	393.6	420.4	356.3	303.8	802.0	230.9	218.4	417.8	468.1	3200.7
Dora.....	735.3	574.8	684.0	629.5	845.7	723.0	568.9	511.4	406.5	423.0	234.3	42.2	6153.8
Ethel.....	361.8	306.2	389.0	363.4	680.3	572.8	309.0	86.0	245.0	260.4	813.9	810.6	5052.0
Houston.....	36.5	402.4	528.5	716.8	837.7	769.4	684.5	636.1	505.1	504.6	229.2	276.8	8912.8
Patsy.....	494.1	580.5	583.0	484.6	550.7	526.8	423.1	363.8	175.4	475.7	373.8	420.4	5499.0
Reddie.....	471.7	431.3	497.1	516.6	637.6	601.5	519.2	466.2	116.0	113.0	.....	.....	4464.0
Rosie.....	480.6	401.4	440.5	445.1	464.8	464.8	358.6	.....	.....	.....	.....	.....	4267.2
Sweet Briar.....	768.2	633.0	689.0	606.8	742.0	543.2	191.8	41.2	.....	.....	893.7	1017.6	4744.9
Topay.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1287.9	1364.5	7769.1

TABLE XXVI.—Per Cent. Fat—Average for Month and Year, 1894.

NAME.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ave.
Allie.....	6.60	6.89	6.16	4.16	3.89	3.63	4.42	4.19	4.44	4.65	4.39	4.78	4.17
Becky.....	4.34	4.34	4.20	6.42	5.87	5.85	5.76	5.49	5.89	.....	.....	.....	5.99
Bess.....	6.35	6.17	6.36	4.02	3.16	2.82	3.16	3.14	3.27	3.48	.....	.....	3.40
Daisy.....	4.98	5.14	5.22	5.85	6.88	5.72	5.28	5.18	5.54	5.68	6.15	6.40	6.02
Dora.....	6.97	7.16	.....	4.72	4.96	4.99	5.29	5.01	5.27	6.22	6.19	8.01	5.19
Ethel.....	.....	.....	.....	4.14	4.21	3.78	4.55	5.08	4.87	4.52	4.59	4.94	4.16
Houston.....	5.49	5.18	4.82	5.11	5.14	5.13	5.42	4.00	5.04	4.05	4.68	5.34	5.13
Nora.....	5.25	5.15	5.06	5.65	5.16	4.84	4.63	4.72	5.04	4.95	5.00	4.95	5.09
Patsy.....	5.63	.....	.....	3.98	3.85	3.94	4.03	4.11	4.40	4.79	4.69	5.14	4.25
Pride.....	5.48	5.21	5.02	5.17	5.12	3.84	5.46	.....	4.40	4.59	5.00	5.14	5.05
Reddie.....	4.92	5.08	4.89	5.04	4.69	4.45	4.37	4.78	4.44	5.40	.....	.....	4.82
Rosie.....	4.16	4.16	4.08	4.18	4.10	3.84	4.37	3.92	3.74	.....	.....	.....	4.03
Sweet Briar.....	5.82	5.84	5.09	5.15	4.92	4.10	4.37	5.63	.....	.....	.....	.....	4.88
Topay.....	4.14	4.09	4.02	4.13	4.26	4.10	4.29	5.63	.....	3.90	3.84	3.64	3.92

TABLE XXVII.—Butter Fat from Each Cow from Each Month and for Year. 1894.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Allie.....	16.94	13.47	13.72	22.94	25.05	21.98	19.88	19.61	18.20	16.14	11.44	6.61	161.85
Beckley.....		7.79	47.51	10.58	26.28	26.70	26.35	23.38	20.14	25.15			176.54
Bess.....	17.14	14.90	17.58	30.62	34.24	30.24	26.62	26.57	24.14	25.15			252.90
Bettie.....	20.52	14.00	18.17	19.00	21.35	16.71	21.58	19.51	16.07	16.40	18.56	20.57	219.37
Daisy.....	18.63	5.01		17.98	21.08	17.97	16.37	15.34	12.39	12.50			166.27
Dora.....				18.37	41.59	36.70	26.65	26.30	24.17	26.54	25.78	28.43	277.75
Ethel.....				26.43	29.29	24.28	22.45	20.38	18.13	18.66	10.52	2.08	172.48
Houston.....	40.55	30.47	32.70	31.84	34.82	29.62	17.27	4.79		2.39	87.78	43.26	805.46
Nora.....	19.64	16.14	18.68	20.46	21.33	17.61	17.68	16.78	12.38	13.02	11.54	13.92	194.43
Patay.....	1.73			29.35	34.42	30.21	27.43	26.08	23.84	24.83	19.38	19.01	233.92
Pride.....	26.94	21.10	26.54	24.95	28.74	20.93	2.92		7.87	22.04	18.64	21.66	222.36
Reddie.....	34.04	29.23	27.20	24.54	25.91	23.64	19.08	17.33	8.14	6.31			216.41
Rosie.....	19.81	18.21	20.19	21.53	26.03	23.17	19.61	18.14					171.07
Sweet Briar.....	26.80	21.63	22.38	22.89	24.87	21.47	18.23	13.55	4.37				232.12
Topay.....	31.67	25.90	27.40	24.96	30.47	21.93	8.47	1.47		35.51	15.14	46.16	304.54
											46.90	49.86	

TABLE XXVIII.—Feed Consumed by Each Cow. 1894.

	Bran	Barley	Corn	Oil Meal	Wheat	Timothy	Prairie Hay	Ensilage	Pasture (days)	Rye Pasture (days)	Oat Hay	Corn Fodder	Roots
Allie.....	809.68	174.13	547.28	213.22	274.99	1488.0	.....	345.0	112.5	18.0	544.5	308.0	215.0
Beckley.....	658.42	293.30	375.18	175.77	.....	1771.0	616.0	1484.0	129.0	.....	627.0	282.0	.....
Beas.....	796.17	203.24	614.12	224.40	9.00	1453.0	.....	1400.0	11.5	18.0	643.5	308.0	183.0
Bettie.....	1118.09	435.36	539.32	268.95	246.99	1846.5	782.0	504.0	111.5	18.0	429.0	665.0	.....
Daisy.....	634.63	310.60	314.09	166.86	38.84	1903.0	607.0	604.0	130.5	.....	363.0	360.0	.....
Dora.....	1071.02	240.76	685.25	297.89	278.49	1703.0	389.0	1890.0	112.5	18.0	544.5	284.0	336.5
Ethel.....	790.83	203.26	495.03	212.24	243.99	1416.0	.....	848.0	129.5	.....	627.0	308.0	156.0
Houston.....	1234.28	461.83	471.62	285.33	294.99	2240.0	598.0	658.0	129.5	.....	660.0	300.0	313.0
Nora.....	886.37	435.68	492.25	207.34	114.49	1820.0	610.0	1454.0	101.5	18.0	468.6	300.0	215.0
Patty.....	865.71	249.86	637.27	256.98	304.99	1916.0	.....	1845.0	112.5	18.0	610.5	294.0	215.0
Pride.....	1167.40	401.95	657.87	307.88	276.99	1929.0	616.0	1454.0	129.5	18.0	363.0	282.0	820.0
Reddie.....	746.27	286.02	472.85	172.62	.....	861.0	.....	2114.0	112.5	.....	643.5	266.0	.....
Rosie.....	658.42	293.30	389.13	161.77	.....	864.0	462.0	1454.0	129.5	.....	669.9	308.0	390.0
Sweet Briar.....	1056.48	422.42	473.19	251.11	245.49	2185.0	462.0	1688.0	111.5	18.0	661.0	138.0	890.0
Topay.....	1173.68	444.71	488.59	275.41	361.50	2508.0	462.0	1608.0	129.5	.....	719.4	238.0	610.0

TABLE XXIX.—Cost of Feed and Dairy Products. 1894.

	Weight of Cow	Cost of Feed	Lbs. of Milk	Cost of 100 lbs. Milk Cts.	Lbs. of Butter Fat	Cost of 1 lb. of Fat Cts.	Lbs. of Butter	Cost of 1 lb. Butter Cts.
Allie.....	1016	\$24.18	8871.7	62.6	161.35	15.0	188.24	12.8
Bettie.....	849	30.41	3643.0	83.7	219.37	13.8	255.93	11.9
Dora.....	843	30.83	5153.8	59.8	277.75	11.1	324.04	9.6
Ethel.....	1022	28.43	4148.3	58.5	172.48	13.5	201.22	11.6
Houston.....	902	32.71	5952.0	55.0	305.48	10.7	356.37	9.2
Nora.....	861	27.40	3912.8	70.1	199.48	13.8	232.67	11.8
Patay.....	930	29.32	5499.0	53.3	233.42	12.5	272.91	10.7
Pride.....	778	32.89	4404.0	74.7	222.35	14.8	259.41	12.7
Sweet Briar.....	1081	31.15	4744.9	65.4	232.12	13.4	270.81	11.5
Topsy.....	1138	34.83	7769.1	44.8	304.54	11.4	355.30	9.8
Total.....	9420	\$297.15	49096.6	.....	2328.77	.....	2718.90	.....
Average.....	942	\$29.72	4909.7	60.6	232.88	12.7	271.89	10.9
" " 1893.....	976	37.82	6407.7	61.1	306.93	12.8	364.6	10.6

The data given in table XXIX. is not deemed as valuable as would be the case had the herd been under normal conditions. However, it will serve a good purpose in showing the marked reduction in flow of milk and yield of butter fat when a herd is subjected to unusual disturbances. Of the ten cows in the list, three aborted—Bettie, Nora and Topsy. Allie and Ethel came into the herd on the first of April, so they are charged with only the feed they received during the nine months they were in the dairy. The other cows are charged with all the feed they consumed during the year whether dry or in milk.

Feeding wheat during November and December makes the cost of dairy products a trifle higher than would have been the case had cheaper feed been used. Taking the year through the feeding was light compared with that of the year previous. The yield falls far below that of 1893, but this decrease is not wholly due to light feeding, for it appears that the unusual disturbance in the herd had much to do with it. Nor is it expected that a herd will do equally well every year. Some years are favorable to large yield while some are the reverse.

The average cost for feed per cow for the year was \$29.72 against \$37.82 in 1893; the average milk yield was 4,909 for 1894 and 6,407 for 1893; the yield of butter fat 232.8 against 306.9 the previous year. The cost for milk and butter production and the relation between cost of production and type of cow are practically the same as was the case the year previous, with the single exception of Sweet Briar whose butter product cost considerably more than was expected. However, the fact that she carried on an average 80 pounds more flesh during the year would, in a measure if not entirely, account for the discrepancy. The increase in the cost of butter fat from Pride has been explained elsewhere. It will be found as the records of this work accumulate that variations in yield of individual cows will occur from year to year just as is the case in field crops; and

so it may happen that in comparing the performances of cows of different types and breeds that now and then a good cow's poor year will be compared with a poor cow's good year to the apparent disadvantage of the former; but the adaptability of a certain style of cow for dairy work has been as fully and clearly demonstrated in practical dairy husbandry as in experimental work.

COMPARING WHEAT WITH BARLEY AND CORN.

In the northwest where wheat is the principal crop it will occasionally occur that because of enormous yield and low market value, wheat could be used to advantage for stock feed, and the object of this experiment was to ascertain its feeding value as compared with a balanced ration composed of the feed stuffs ordinarily used.

The Rations.—In the general plan of the experiment it was intended to gradually change the herd to a grain ration composed wholly of ground wheat, but after a preliminary feeding of two weeks it was feared that the cows would tire of it before the close of the experiment, so two rations were made of the food stuffs in kind and quantity indicated in the following formulae:

TABLE XXX.—Wheat Ration.

FOOD.	Lbs.	D. M.	DIGESTIBLE			Cost. Cents.
			Pro.	C-H	Fat.	
Bran.....	6	5.46	.75	2.52	.21	3.3
Wheat.....	7	6.23	.77	4.10	.10	7.0
Oil Meal.....	1	.94	.27	.38	.06	1.3
Timothy.....	16	14.12	.54	6.94	.20	3.8
Roots.....	10	1.35	.11	1.02	.01	1.0
		28.10	2.44	14.96	.58	16.4

Total digestible nutrients, 17.98. Nutritive ratio, 1:6.7.

TABLE XXXI.—Standard Ration.

FOOD.	Lbs.	D. M.	DIGESTIBLE.			Cost. Cents.
			Pro.	C-H	Fat.	
Bran.....	6	5.46	.75	2.52	.21	3.3
Barley.....	4	3.63	.36	2.47	.07	2.8
Corn.....	3	2.70	.27	2.05	.09	2.1
Oil meal.....	1	.94	.27	.38	.06	1.3
Timothy.....	16	14.12	.54	6.94	.20	4.4
Beets.....	10	1.35	.11	1.02	.01	1.0
		28.20	2.30	15.38	.64	14.9

Total digestible nutrients, 18.32. Nutritive ratio, 1:7.3.

The cows were not all fed the quantity indicated in the two rations, but the grain was always mixed in the proportion stated in the formulae and each cow received as much as she could make use of. The amount actually consumed by each will appear in the proper table.

The Cows Employed.—The following table gives the names of the cows selected for the experiment, age, breeding, weight at beginning and close of experiment, date of calving and time of service.

TABLE XXXII.—Giving List of Cows in the Trial.

NAME	Age	Breed	Wt. at Beginning	Wt. at Close	Date of Calving	Date of Service
Bettie.....	9	Guernsey	842	910	* July 2, 1894	Dec. 17, 1894
Dora.....	12	Jersey	862	900	April 16, 1894	Sept. 4, 1894
Lou.....	8	Holstein	1175	1128	Oct. 23, 1894	Jan. 30, 1895
Sweet B.....	11	Guernsey	1052	1084	Nov. 17, 1894	Dec. 17, 1894
Tricksey.....	2	Guernsey	723	746	Oct. 9, 1894	Jan. 2, 1895
Quidee.....	3	Holstein	786	867	Oct. 23, 1894	Jan. 3, 1895
Beckley.....	3	Grade Jersey	838	852	Sept. 8, 1894	Dec. 25, 1894
Countess.....	10	Holstein	1193	1179	Nov. 17, 1894	Feb. 2, 1895
Houston.....	11	Jersey-Guernsey	919	920	Oct. 29, 1894	Feb. 19, 1895
Lydia.....	6	Swiss	1013	1080	Nov. 4, 1894	Feb. 16, 1895
Olive.....	11	Grade Guernsey	790	815	Nov. 8, 1894	Jan. 14, 1895
Topsy.....	9	Grade Holstein	1131	1153	Oct. 10, 1894	Dec. 23, 1894

* Aborted.

The cows were divided into two groups of six each and the time of the experiment into four periods of two weeks each, with a week intervening for preliminary feeding. The cows were in fine working condition during the experiment and nothing occurred which would produce abnormal results either in yield of milk or butter fat. During period I. group 1 was fed on the standard ration and group 2 on the wheat ration, each group receiving timothy hay and roots for roughage though not the same amount of the former. During period II. group 1 received the wheat ration while group 2 was fed on the standard ration, and during periods III. and IV. the same routine was repeated.

The following table gives the amount of grain, hay and roots consumed and milk and butter fat produced by each cow in group 1.:

COMPARING A WHEAT WITH A STANDARD RATION.

TABLE XXXIII.—Giving Food Consumed and Milk and Butter Fat Produced by Group I.

NAME.	PERIOD I.—STANDARD RATION.					PERIOD II.—WHEAT RATION.				
	Grain	Hay	Roots	Milk	Butter Fat	Grain	Hay	Roots	Milk	Butter Fat
Bettie	140	168	70	141.6	9.26	140	168	70	142.2	9.54
Dora	154	182	70	216.8	13.84	154	182	87.5	206.8	12.92
Lou	168	210	140	545.1	22.34	148	210	140	535.2	16.61
Quilice	164	196	70	365.9	12.18	154	196	70	395.9	12.89
Sweet B.	168	196	140	454.4	19.59	175	210	140	456.7	21.56
Tricacy	140	168	70	231.4	10.25	140	168	70	234.3	11.72
Total	924	1120	560	1955.2	87.46	931	1134	577.5	1939.1	87.28

NAME.	PERIOD III.—STANDARD RATION.					PERIOD IV.—WHEAT RATION.				
	Grain	Hay	Roots	Milk	Butter Fat	Grain	Hay	Roots	Milk	Butter Fat
Bettie	140	168	70	143.1	9.88	140	182	70	134.8	9.45
Dora	164	182	106	214.6	13.36	154	186	106	202.9	13.07
Lou	168	224	140	532.9	18.70	175	238	140	615.7	19.32
Quilice	164	206	70	342.3	12.06	164	210	108	367.2	13.74
Sweet B.	186	224	140	418.7	20.71	196	238	140	400.9	21.56
Tricacy	140	168	70	243.1	11.66	140	182	70	231.1	12.56
Total	952	1102	595	1899.7	85.87	959	1246	630	1842.6	89.72

Upon examination of the table it will be observed that while there was a slight variation in yield of dairy products by some of the cows, and while there was a gradual shrinkage in yield of milk, there was only a slight shrinkage in butter fat by the group during the third period, and this was more than made up in the last period, when it gave over two pounds more of butter fat than it did during the first period.

The following table gives the amount of grain, hay and roots consumed and milk and butter fat produced by each cow in group 2:

TABLE XXXIV.—Giving Pounds of Food Consumed and Milk and Butter Fat Produced by Group II.

NAME.	PERIOD I.—WHEAT RATION.					PERIOD II.—STANDARD RATION.				
	Grain	Hay	Roots	Milk	Butter Fat	Grain	Hay	Roots	Milk	Butter Fat
Beckley 2.....	140	168	70	172.0	9.30	140	168	70	200.7	11.77
Countess.....	196	224	140	666.4	15.72	196	224	140	647.2	15.08
Houston.....	168	182	70	374.2	19.98	168	182	70	353.8	19.43
Lydia.....	196	224	70	436.8	14.53	196	224	105	458.3	14.90
Oliver.....	140	168	70	408.5	15.23	140	168	70	402.4	14.75
Topsy.....	203	252	140	623.4	22.96	217	252	140	621.7	23.37
Total.....	1043	1218	560	2681.3	97.72	1057	1218	595	2684.1	99.30

NAME.	PERIOD III.—WHEAT RATION.					PERIOD IV.—STANDARD RATION.				
	Grain	Hay	Roots	Milk	Butter Fat	Grain	Hay	Roots	Milk	Butter Fat
Beckley 2.....	126	168	70	183.9	10.60	126	182	70	196.6	10.96
Countess.....	196	224	140	602.1	15.06	196	236	140	616.5	15.44
Houston.....	168	182	70	344.5	20.46	168	196	70	327.5	15.37
Lydia.....	196	224	140	450.3	16.76	210	238	140	447.7	15.70
Oliver.....	126	168	70	384.0	14.65	126	182	70	382.0	14.30
Topsy.....	224	252	140	619.9	23.26	224	266	140	620.7	23.19
Total.....	1086	1218	630	2584.7	99.67	1050	1302	630	2543.0	98.46

Upon examination of the totals of butter fat produced by the group it appears that there was no marked difference in the yield of butter fat during the different periods. There was a slight increase during the second period when on the standard ration, but this was more than made good by the yield given in the third period on the wheat ration. Combining the results obtained by the two groups of cows while fed on the standard ration we have the following table:

SUMMARY OF RESULTS.

TABLE XXXV.—Giving the Pounds of Food Consumed and Milk and Butter Fat Produced with the Standard Ration.

	Grain.	Hay.	Beets.	Milk.	Butter Fat.
Lot 1, Period I.....	924	1120	580	1955.2	87.46
Lot 1, Period III.....	952	1116	595	1889.7	85.87
Lot 2, Period II.....	1057	1218	595	2684.1	99.30
Lot 2, Period IV.....	1050	1302	630	2543.0	98.46
	3983	4802	2360	9072.0	371.09

Combining the results obtained by the two groups while fed on the wheat ration we have the following table:

TABLE XXXVI.—Giving the Pounds of Food Consumed and Milk and Butter Fat Produced While Feeding the Wheat Ration.

	Grain.	Hay.	Roots.	Milk.	Butter Fat
Lot 2, Period I.....	1043	1218	560	2681.3	97.72
Lot 2, Period III.....	1036	1218	560	2584.7	99.67
Lot 1, Period II.....	931	1134	577	1939.1	87.28
Lot 1, Period IV.....	959	1246	630	1842.6	89.72
	3969	4816	2327	9047.7	374.39

	Milk.		Butter fat.
Standard ration.....	9072.0	Wheat ration.....	374.39
Wheat ration.....	9047.7	Standard ration.....	371.09
In favor of Standard Ration.....	24.3	In favor of Wheat Ration.....	3.30

The amount of grain and roughage consumed by the two groups while taking the two kinds of grain rations was practically the same with the exception that while eating the standard ration they received 53 pounds more of roots than when the wheat ration was fed. In comparing the yield of dairy products from the two rations it is found that 24.3 pounds more milk was secured from the standard ration and 3.3 pounds more butter fat from the wheat ration. This is believed to be merely incidental since such slight variations occur where there is no change of feed. The experiment indicates that by weight wheat has a feeding value equal to barley and corn.

DRY MATTER IN THE RATIONS.

In comparing the feeding value of different food stuffs the organic matter contained in each should be considered as well as the weight of the different foods. This seems especially important where a series of experiments are to be made to get a better understanding of the mysteries of animal nutrition, as is the case at this station. If there is any special virtue in certain feed stuffs or in certain nutrients in all kinds of feed it is of vital importance that it should be discovered and clearly demonstrated by American experiment stations. With a view of accumulating material data upon this subject, comparisons will be made in the dry matter and digestible nutrients ~~or digestible protein~~ contained in the feed stuffs as well as simply a comparison of the weight of the feed consumed. It is especially important to reduce to some common factor all feed that varies greatly in per cent. of water content and digestibility.

The following table gives the amount of dry matter consumed by each cow determined by actual chemical analysis of a sample of each of the feed stuffs used during the experiment, the total amount of dry matter consumed and milk and butter fat produced by the group with each ration and the average number of pounds of dry matter required by the group with the different rations:

TABLE XXXVII.—Giving Dry Matter Consumed and Milk and Butter Fat Produced by Group I.

NAME.	STANDARD RATION				WHEAT RATION			
	Dry Matter Lbs.	Milk Lbs.	Butter Fat Lbs.	D. M. to produce 1 Lb. Butter Fat	D. M. Lbs.	Milk Lbs.	Butter Fat Lbs.	D. M. to Produce 1 Lb. Butter Fat
Bettie.....	570.108	284.7	18.64	30.585	580.510	277.0	18.99	30.559
Dora.....	625.009	431.4	27.20	22.478	637.527	409.7	26.04	24.483
Lon.....	728.446	1075.0	41.04	17.702	742.770	1048.9	37.93	19.583
Quidec.....	645.008	708.2	24.24	26.409	659.939	723.1	26.62	24.791
Sweet B.....	739.536	868.1	40.30	18.350	749.084	857.6	43.14	17.864
Trickey.....	570.108	474.5	21.91	26.021	580.510	465.4	24.28	23.909
Total.....	3876.215	3844.9	173.33	22.36	3950.340	3781.7	177.00	22.31
Average.....								

TABLE XXXVIII.—Giving Dry Matter Consumed and Milk and Butter Fat Produced by Group II.

NAME.	WHEAT RATION				STANDARD RATION			
	Dry Matter Lbs.	Milk Lbs.	Butter Fat Lbs.	D. M. to Pro- duce 1 lb. Butter Fat	Dry Matter Lbs.	Milk Lbs.	Butter Fat Lbs.	D. M. to Pro- duce 1 lb. Butter Fat
Beckley.....	555.520	355.9	19.90	27.280	569.744	397.3	22.73	25.066
Countess.....	786.968	1268.5	30.77	25.576	814.436	1265.7	30.52	26.685
Houston.....	644.284	718.7	40.44	15.932	658.098	681.3	38.30	17.183
Lydia.....	777.518	887.1	30.28	25.678	810.075	906.0	30.60	26.473
Olive.....	555.520	792.5	29.78	18.654	569.744	734.4	29.05	19.613
Topsy.....	867.322	1243.3	46.22	18.765	906.063	1242.4	46.56	19.460
Total.....	4187.132	5266.0	197.39	21.21	4328.160	5227.1	197.76	21.88
Average.....								

TABLE XXXIX.—Giving a Summary of Results Obtained in Comparing a Wheat with a Standard Ration.

	STANDARD RATION				WHEAT RATION			
	Dry Matter lbs.	Milk lbs.	Butter Fat lbs.	D. M. to Produce 1 lb. Butter Fat	Dry Matter lbs.	Milk lbs.	Butter Fat lbs.	D. M. to Produce 1 lb. Butter Fat
Lot I.....	3876.215	3844.9	173.33	22.36	3950.340	3781.7	177.00	22.31
Lot II.....	4328.160	5227.1	197.76	21.88	4187.132	5266.0	197.39	21.21
Total.....	8204.375	9072.0	371.09		8137.472	9047.7	374.39	
Average.....				22.10				21.73

TABLE XL.—Giving Digestible Protein Consumed and Milk and Butter Fat Produced.

	STANDARD RATION				WHEAT RATION			
	Digestible Protein lbs.	Milk lbs.	Butter Fat lbs.	D. Pro. to Produce 1 lb. Butter Fat	Digestible Protein lbs.	Milk lbs.	Butter Fat lbs.	D. Pro. to Produce 1 lb. Butter Fat
Lot I.....	311.661	3844.9	173.33	1.79	322.434	3781.7	177.00	1.82
Lot II.....	358.267	4227.1	197.76	1.81	365.428	5266.0	197.39	1.85
Total.....	669.918	8072.0	371.09	1.80	687.860	9047.7	374.39	1.83
Average.....								

By calculating the digestible protein contained in the feed consumed during the trial we find that when the cows were taking the standard ration they returned a pound of butter fat for every one and eight-tenths of a pound of digestible protein consumed; and with the wheat ration it required one and eighty-three hundredths pounds. It appears that there is practically no difference between the feeding value in weight of ground wheat and ground corn and barley.

COMPARING PRAIRIE HAY WITH TIMOTHY.

In the states of Minnesota and North and South Dakota there are vast areas of land that are still covered with wild grasses that are used for roughage in both milk and meat production. It has been quite a common belief that good dairy products can only be made by using such hay as clover, timothy, red top, etc. The many premiums that have been won in state and national contests on butter made from prairie hay has shown that it yields a product at least equal to that produced from tame hay. To more carefully study the feeding value of wild hay grown on river bottoms, this experiment was made, which is in a measure a duplicate of that reported in Bulletin 35.

Character of the Hay Feed.—The prairie hay used was from bottom land along the Chippewa river in Swift county and was rather coarse in blade, cut in good season and well cured, differing from that used in the former experiment, which was upland hay. The cows were exceedingly fond of it and ate all that was given them. The timothy was medium fine and rather short, having been grown on light soil. It was of good color, cut early and not cured too much, as is almost universally the case in this climate with hay intended for dairy cows. In addition to the hay the cows were fed ensilage and grain. The ration was composed of six parts bran, two parts ground corn, five parts ground wheat and one part cottonseed meal, for the grain; and fourteen pounds of ensilage and eighteen pounds of hay for the roughage. Each cow was fed as much as she would eat up clean.

The Cows in the Experiment.—Twelve cows were selected for the experiment. They were divided into two groups, each giving about an equal amount of milk and butter fat. The following table gives the name, age, breeding, weight at beginning and close of experiment, date of calving and when bred.

TABLE XLI.—*Prairie Hay vs. Timothy Hay. 1895.*

NAME.	Age	Breed	Wt. at Beginning	Wt. at Close	Date of Calving	Date of Service
I. Beckley 2.....	3	Grade Jersey	850	865	Sept. 8, 1894	Dec. 25, 1894
o Countess.....	10	Holstein	1188	1190	Nov. 17, 1894	Feb. 2, 1895
t Houston.....	11	Jersey-Guernsey	925	895	Oct. 29, 1894	Feb. 19, 1895
Lou.....	8	Holstein	1140	1115	Oct. 23, 1894	Jan. 30, 1895
Olive.....	11	Grade Guernsey	800	792	Nov. 8, 1894	Jan. 14, 1895
I. Reddie.....	2	Grade Jersey	750	786	Dec. 19, 1894	Jan. 9, 1895
L. Belle.....	8	Gr. Shorthorn	935	950	.....	Jan. 27, 1895
o Lydia.....	5	Brown Swiss	1080	1085	Nov. 4, 1894	Feb. 16, 1895
t Quidee.....	3	Holstein	865	874	Oct. 23, 1894	Jan. 3, 1895
Sweet B.....	11	Guernsey	1090	1060	Nov. 17, 1894	Dec. 17, 1894
Topsy.....	9	Grade Holstein	1145	1172	Oct. 10, 1894	Dec. 23, 1894
II. Tricksey.....	2	Guernsey	745	760	Oct. 9, 1894	Jan. 2, 1895

The experiment was divided into four periods of two weeks each with a week intervening for preliminary feeding, which was begun on the 11th of February and continued one week; the experiment proper commenced the morning of the 18th and continued until the evening of March 3d, lot 1 receiving grain, ensilage and prairie hay, while lot 2 received grain, ensilage and timothy hay. Period II. commenced March 4th, continuing to March 14th, inclusive. Lot 1 was fed grain, ensilage and timothy, and lot 2 grain, ensilage and prairie hay. This program was repeated during periods III. and IV., with the exception that each was shortened one week for the reason that the weather was getting mild and it was feared that there would be an abnormal shrinkage by some of the cows on account of a longing to get to pasture. Later on such really proved to be the case, and it was exceedingly fortunate that period III. was shortened one week, for period IV. could not have been continued another week. We find that the week before going to pasture is the most critical one in the whole year. Cows scent the new grass and some are apt to eat a very light ration and shrink in milk and sometimes, though not always, in butter fat.

The grain, ensilage and hay consumed and milk and butter fat produced by lot 2 during the four periods is given in the following table:

INVESTIGATION IN MILK PRODUCTION.

TABLE XLII.—Feed Consumed and Milk and Butter Fat Produced by Lot 1.

NAME.	PERIOD I.—Feb. 18-March 3					PERIOD II.—March 11-24				
	Grain	Ensil- lage	Prairie Hay	Milk	Butter Fat	Grain	Ensil- lage	Tim- othy	Milk	Butter Fat
Bectley 2.....	126	112	168	195.7	11.40	126	112	168	184.3	10.27
Countess.....	152	168	224	580.8	15.88	182	168	224	609.7	14.41
Houston.....	198	168	182	342.8	19.41	168	168	182	363.9	19.36
Lou.....	198	168	210	458.5	17.64	168	168	210	470.1	16.84
Olive.....	126	140	168	303.3	13.02	136	140	168	306.9	12.64
Reddie 2.....	119	112	168	213.4	10.90	136	112	168	202.9	10.76
	899	868	1120	2094.5	88.26	896	868	1120	2137.8	84.27

NAME.	PERIOD III.—April 1-7					PERIOD IV.—April 15-21				
	Grain	Ensil- lage	Prairie Hay	Milk	Butter Fat	Grain	Ensil- lage	Tim- othy	Milk	Butter Fat
Bectley 2.....	63	63	84	86.8	4.95	63	63	84	86.3	4.60
Countess.....	98	84	119	250.1	7.34	98	84	119	284.9	6.93
Houston.....	84	84	91	168.9	8.96	84	84	91	169.5	8.58
Lou.....	84	84	105	211.4	7.82	84	84	105	181.5	6.18
Olive.....	63	70	84	158.8	5.88	63	70	84	141.3	5.60
Reddie 2.....	70	70	84	96.4	5.08	70	63	84	95.9	5.01
	462	465	567	982.4	39.71	462	448	567	959.4	36.88

The cows did not maintain a uniform flow of milk and yield of butter fat during the four periods. Houston and Reddie 2d kept up a full flow during the first two periods and the latter shrank in yield of butter fat but a trifle during the last two periods. Aside from these two the shrinkage was gradual and quite uniform with lot 1.

The table on opposite page gives the amount of grain, ensilage and hay eaten and milk and butter fat produced by each cow in lot 2 during the four periods:

With lot 2 there was as marked a shrinkage during the third period as was the case with lot 1, which is an indication that the shrinkage was caused by conditions other than the feed. During the time intervening between periods II. and III., lot 2 actually gained in yield of butter fat. Upon examination of the Foreman's Daily Report it is found that during period III. the cows were turned into the yard during the day, which was not the case during the two preceding periods. It also appears that there was an unusual disturbance in the herd during the month of April, such as change in milkers, caused by the School of Agriculture closing the last of March; change in the order of milking certain cows; leaving the cows in the yard during pleasant days and then confining them in the barn during cold rains or raw windy days.

To so manage a herd of dairy cows that no change in flow of milk and yield of butter fat is produced except by the feed or conditions under trial is a very difficult matter, and it is only by numerous trials and being entirely familiar with all animals used in the experiment and knowing all conditions bearing upon it that reliable data can be obtained.

TABLE XLIII.—Feed Consumed and Milk and Butter Fat Produced by Lot 2.

NAME.	PERIOD I.—Feb. 18-March 3					PERIOD II.—March 11-24				
	Grain	Basilage	Timothy	Milk	Butter Fat	Grain	Basilage	Prairie Hay	Milk	Butter Fat
Belle.....	140	126	154	262.7	11.24	140	126	147	276.3	11.67
Lydia.....	168	168	224	416.9	15.01	168	168	217	390.7	14.23
Quidee.....	140	140	182	361.1	12.81	140	140	182	378.7	13.45
Sweet Briar.....	168	168	210	376.7	20.84	168	168	210	361.2	19.18
Topay.....	196	196	252	612.3	21.87	196	196	252	560.5	21.58
Trickacy 2.....	112	112	154	220.0	11.61	112	112	154	224.3	12.18
	824	910	1176	2249.7	92.88	824	910	1162	2191.7	92.29

NAME.	PERIOD III.—April 1-7					PERIOD IV.—April 15-21				
	Grain	Basilage	Timothy	Milk	Butter Fat	Grain	Basilage	Prairie Hay	Milk	Butter Fat
Belle.....	70	70	70	126.8	5.36	70	70	70	138.1	5.50
Lydia.....	91	70	105	182.7	6.25	91	70	105	183.0	6.49
Quidee.....	70	70	91	174.8	5.99	70	77	91	189.4	6.62
Sweet Briar.....	84	84	105	177.6	9.05	84	84	105	180.2	8.87
Topay.....	98	98	126	266.2	9.00	98	98	126	258.6	9.86
Trickacy 2.....	63	70	84	106.5	5.80	63	70	84	110.9	5.72
	476	462	581	1038.6	42.34	476	469	581	1040.2	42.06

Combining the results obtained from lots 1 and 2 when prairie hay was fed we have the following table:

TABLE XLIV.—Yield when Prairie Hay was Fed.

	Grain	Ensilage	Prairie Hay	Milk	Butter Fat
Lot 1 P. I.....	889	868	1120	2094.6	88.25
Lot 1 P. III.....	462	465	567	982.4	39.71
Lot 2 P. II.....	824	910	1162	2191.7	92.29
Lot 2 P. IV.....	476	489	581	1040.2	42.05
	2651	2702	3430	6308.8	262.30

Combining the results obtained from lots 1 and 2 when timothy was fed we have the following table:

TABLE XLV.—Yield when Timothy was Fed.

	Grain	Ensilage	Prairie Hay	Milk	Butter Fat
Lot 1 P. II.....	896	868	1120	2137.8	84.27
Lot 1 P. IV.....	462	448	567	959.4	36.88
Lot 2 P. I.....	824	910	1176	2249.7	92.88
Lot 2 P. III.....	476	462	581	1033.6	42.34
	2658	2688	3444	6380.5	256.37

Butter
Fat
Prairie Hay... 262.30
Timothy..... 256.37

5.93 Favor Prairie Hay.

Milk
Timothy..... 6380.5
Prairie Hay... 6308.8

71.7 Favor Timothy.

Comparing the milk and butter fat yielded when the two kinds of hay were fed it is found that the cows produced 71.7 pounds more milk when timothy was fed and 5.93 pounds more butter fat when prairie hay was fed.

The following table gives the average weight of each cow during the four periods and the average weight of each lot at the beginning and the close of the experiment:

TABLE XLVI.—Average Weight of Each Cow During Each Period.

NAME.		February 11 to March 3	March 4 to March 24	March 25 to April 7	April 8 to April 21
LOT 1	Beckley.....	844	848	873	863
	Countess.....	1195	1177	1175	1190
	Houston.....	914	908	908	893
	Lou.....	1138	1110	1100	1112
	Olive.....	800	793	790	793
	Reddie 2.....	743	760	785	786
Average.....		940			939
LOT 2	Belle.....	938	960	960	948
	Lydia.....	1071	1088	1076	1083
	Quidee.....	867	891	870	874
	Sweet Briar.....	1090	1063	1055	1060
	Topsy.....	1152	1150	1136	1173
	Tricksey 2.....	739	748	745	760
Average.....		943			983

To show the difference in cost of production when the two kinds of hay were fed four tables are submitted, showing the amount of feed consumed and milk and butter fat produced and cost of producing a hundred pounds of milk and a pound of butter fat by each cow during the four periods.

The ruling price of feed stuffs used in the experiment during the winter of 1894-95 were:

TABLE XLVII.—Giving Prices of Feed Used.

FOOD.	Per Ton	Per Pound Cents
Timothy.....	\$5.60	.28
Prairie Hay.....	3.20	.16
Wheat.....	20.00	1.00
Bran.....	11.00	.55
Barley.....	14.00	.70
Corn.....	14.00	.70
Oil Meal.....	26.00	1.30
Cotton Seed Meal.....	28.00	1.40
Ensilage.....	2.00	.10

To examine the difference in cost of production of butter fat with the two kinds of hay, and incidentally to note the cost of producing butter from the different cows, the following tables were prepared, showing the cost of the feed consumed by each cow, the milk and butter fat produced and the cost of a pound of butter fat:

TABLE XLVIII.—Cost of Butter Fat with Lot 1.

NAME.	Period	TIMOTHY HAY				PRAIRIE HAY			
		Cost of feed	Milk	Butter fat	Cost of 1 lb. Butter fat. cts.	Cost of feed	Milk	Butter fat	Cost of 1 lb. Butter fat. cts.
Beckley 2	II	\$1.582	184.3	10.27	15.4	\$1.380	195.7	11.40	12.1
	IV	.798	86.3	4.60	17.4	.897	86.8	4.65	15.0
Countess	II	2.228	609.7	14.41	15.5	1.970	580.8	15.88	12.4
	IV	1.194	284.9	6.93	17.2	1.051	280.1	7.34	14.3
Houston	II	2.010	363.9	19.36	10.4	1.791	342.8	19.41	9.2
	IV	1.005	169.5	8.56	11.7	.896	168.9	8.96	10.0
Lou	II	2.058	470.1	16.84	12.4	1.838	458.5	17.64	10.4
	IV	1.044	181.5	6.18	16.9	.918	211.4	7.82	11.7
Olive	II	1.609	306.9	12.64	12.7	1.408	303.3	13.02	10.8
	IV	.805	141.3	5.60	14.4	.704	138.8	5.88	11.9
Reddie 2	II	1.582	202.9	10.75	14.7	1.324	213.4	10.90	12.1
	IV	.853	55.9	5.01	17.0	.760	96.4	5.06	15.0
Total		16.808	3097.2	121.15		14.735	3076.9	127.96	
Average					13.9				11.5

TABLE XLIX.—Cost of Butter Fat with Lot 2.

NAME.	Period	TIMOTHY HAY				PRAIRIE HAY			
		Cost of feed	Milk	Butter fat	Cost of 1 lb. Butter fat. cts.	Cost of Feed	Milk	Butter Fat	Cost of 1 lb. Butter fat. cts.
Belle	I	\$1.667	262.7	11.24	14.8	\$1.471	276.3	11.67	12.6
Belle	III	.821	126.8	5.35	15.3	.787	138.1	5.50	13.4
Lydia	I	2.127	416.9	16.01	14.2	1.847	390.7	14.23	12.9
Lydia	III	1.086	182.7	6.25	17.4	.960	183.0	6.49	14.8
Quidee	I	1.760	361.1	12.31	13.7	1.541	373.7	13.45	11.5
Quidee	III	.880	174.8	5.99	14.7	.778	169.4	5.62	13.8
Sweet Briar	I	2.088	376.7	20.84	10.0	1.836	361.2	19.18	9.6
Sweet Briar	III	1.044	177.6	9.05	11.5	.918	180.2	8.87	10.3
Topsy	I	2.456	612.3	21.37	11.5	2.153	560.5	21.58	10.0
Topsy	III	1.228	268.2	9.90	12.4	1.077	258.6	9.85	10.9
Tricksey 2	I	1.431	220.0	11.61	12.3	1.247	224.3	12.18	10.3
Tricksey 2	III	.805	105.5	5.80	13.9	.704	110.9	5.72	12.3
Total		17.393	3283.3	135.22		15.269	3231.9	134.34	
Average					12.8				11.4

Combining the cost of feed and yield of milk and butter fat of lots 1 and 2 when timothy was fed and the cost of feed and milk and butter fat produced by the two lots when prairie hay was fed, it appears that with the timothy hay it cost 13.3 cents to produce a pound of butter fat and with prairie hay it cost 11.5 cents, being a difference of 1.85 cents per pound in favor of prairie hay.

INVESTIGATION IN MILK PRODUCTION.

SUMMARY OF RESULTS.

	TIMOTHY HAY				PRAIRIE HAY			
	Cost of Feed	Milk	Butter Fat	Cost of Butter Fat Cents	Cost of Feed	Milk	Butter Fat	Cost of Butter Fat Cents
Lot 1.....	\$16.81	3097.2	121.15	13.9	\$14.73	3076.9	127.96	11.5
Lot 2.....	17.89	3288.3	135.22	12.8	15.27	3231.9	134.34	11.4
Total.....	\$34.20	6380.5	256.57	.....	\$30.00	6308.8	262.30	.....
Average.....	.....	.....	.....	13.3	.....	.....	.....	11.45

The difference in cost of production is due simply to the difference in the price of timothy and prairie hay. In a similar experiment reported in Bulletin 35 on page 72 it appears that when grain and timothy were fed it cost 18.8 cents to produce a pound of butter fat and with prairie hay it cost 16 cents or 17.5 per cent. less with prairie hay, while in this trial it cost 16.15 per cent. less to produce butter fat when prairie hay is fed than it did with timothy.

In this experiment it cost for feed \$64.20 to produce 518.67 pounds of butter fat, which is an average of 12.3 cents per pound. In the experiment reported in Bulletin 35, which commenced the 12th of February and ended the 29th of April the year prior, it cost \$43.51 to produce 249.21 pounds of butter fat from groups 1 and 2, being an average cost per pound of 17.4 cents. With groups 3 and 4 it cost 16.3 cents.

The price of feed stuffs during the year 1893 and for the winter of 1893-94, reported in Bulletin 35, and for the year 1894 and the winter of 1894-95 were the same, but the rations fed in the two trials, comparing timothy with prairie hay, were quite different as to cost and feed stuffs used. In the first experiment the ration contained 6 pounds of bran, 3 pounds of barley, 3 pounds of corn and 1.6 oilmeal, while in this we have 6 of bran, 5 of wheat and 1 of cottonseed meal. Since wheat, barley and corn have practically the same feeding value, pound for pound, and the cows being charged a cent a pound for wheat, while corn and barley could be substituted for .7 of a cent per pound, the cost of production is higher than would be the case if corn and barley had been fed in place of the wheat.

To further examine the bearing the two kinds of hay have on butter production, comparisons will be made upon the basis of dry matter and digestible nutrients in the two rations fed during the experiment:

TABLE L.—Composition of Feed Stuffs Used in the Experiment.

FOOD.	PERCENTAGE COMPOSITION						POUNDS DIGESTIBLE			
	D. M.	Water	Ash	Ether Ex.	Crude Pro.	Crude Fibre	Nitrogen Ex. Free	Pro.	C. H.	Ether Ex.
Bran.....	91.00	9.00	4.02	5.30	14.00	8.90	58.78	12.5	42.1	3.6
Corn.....	90.23	9.77	1.77	4.20	9.58	1.86	72.83	9.2	68.6	8.1
Wheat.....	89.05	10.95	2.20	2.17	14.18	2.83	67.67	11.0	68.6	1.5
Cottonseed Meal.....	91.86	8.14	7.96	11.20	44.38	5.61	22.71	32.0	20.2	10.0
Nailage.....	24.59	75.41	1.39	.87	2.14	5.04	15.35	1.2	15.0	.6
Prairie Hay.....	88.02	11.98	6.67	2.74	5.95	30.44	41.85	3.5	41.8	1.4
Timothy.....	88.27	11.73	5.22	2.61	5.90	31.04	44.49	3.4	43.4	1.3

TABLE LI.—Dry Matter Consumed and Milk and Butter Fat Produced by Lot 1.

NAME.	PRAIRIE HAY.				TIMOTHY HAY.			
	Dry Matter Lbs.	Butter Fat Lbs.	Milk Lbs.	Dry Matter to 1 lb. Butter Fat	Dry Matter Lbs.	Butter Fat Lbs.	Milk Lbs.	Dry Matter to 1 lb. Butter Fat
Beckley.....	285.40	11.40	195.7	25.30	288.32	10.27	184.3	28.12
Beckley.....	158.48	4.65	86.8	34.08	146.37	4.60	86.3	31.82
Countess.....	402.64	15.88	280.1	25.36	403.20	14.41	608.7	27.98
Countess.....	207.48	7.34	128.6	28.26	214.13	6.98	284.9	30.87
Houston.....	353.08	19.41	18.19	18.19	353.64	19.36	193.5	18.26
Houston.....	176.54	8.96	168.9	19.70	176.82	8.56	198.5	20.65
Lou.....	377.72	17.64	458.5	21.41	378.28	16.84	470.1	22.46
Lou.....	188.86	7.82	211.4	24.15	189.14	6.18	181.5	30.61
Olive.....	295.32	13.02	303.3	22.72	296.24	12.64	306.9	23.44
Olive.....	147.91	5.88	138.8	25.15	148.12	5.60	141.3	26.45
Reddie 2d.....	282.17	10.90	213.4	25.88	283.85	10.75	202.9	26.87
Reddie 2d.....	154.28	5.06	96.4	30.49	154.49	5.01	95.9	30.85
Total.....	3083.36	127.96	3076.9	28.71	3088.07	121.15	3087.2	26.07
Average.....								

TABLE LII.—Dry Matter Consumed and Milk and Butter Fat Produced by Lot 2.

NAME.	TIMOTHY HAY.					PRAIRIE HAY				
	Dry Matter Lbs.	Milk Lbs.	Butter Fat Lbs.	Butter Fat to 1 lb. Butter Fat	Dry Matter	Dry Matter Lbs.	Milk Lbs.	Butter Fat Lbs.	Butter Fat to 1 lb. Butter Fat	Dry Matter
Belle.....	293.16	292.7	11.24	26.08	286.58	276.3	11.67	24.56	24.56	24.56
Belle.....	142.17	136.8	6.86	26.57	141.96	138.1	6.80	25.81	25.81	25.81
Lydia.....	390.90	416.9	16.01	26.02	383.88	390.7	14.23	28.63	28.63	28.63
Lydia.....	192.01	182.7	6.26	30.72	191.73	188.0	6.49	29.64	29.64	29.64
Quince.....	311.08	361.1	12.81	24.28	320.88	378.7	13.46	28.86	28.86	28.86
Quince.....	160.72	174.8	6.99	28.88	162.12	169.4	6.92	18.84	18.84	18.84
Sweet Briar.....	378.28	376.7	20.84	28.16	377.72	361.2	19.13	21.79	21.79	21.79
Sweet Briar.....	189.14	177.6	9.95	20.90	188.86	180.6	21.56	20.70	20.70	20.70
Topsy.....	447.44	612.3	21.37	20.94	446.74	598.6	19.98	22.68	22.68	22.68
Topsy.....	223.72	286.2	9.80	22.60	223.37	258.6	12.76	21.84	21.84	21.84
Tricacy 2d.....	264.04	220.0	11.61	22.74	263.62	244.3	6.72	25.86	25.86	25.86
Tricacy 2d.....	148.12	106.5	6.80	26.54	147.91	110.9	134.34	23.34	23.34	23.34
Total.....	3140.48	3283.3	135.22	23.22	3135.87	3281.9	134.34	23.34	23.34	23.34
Average.....										

TABLE LIII.—Comparing Yield of Milk and Butter Fat with Dry Matter as a Basis.

	PRAIRIE HAY				TIMOTHY			
	D. M.	Milk	Butter Fat	D. M. to Produce 100 Lbs. of Milk	D. M.	Milk	Butter Fat	D. M. to Produce 100 Lbs. of Milk
Lot 1	3033.38	3076.9	127.96	98.59	3038.07	3097.2	121.15	98.09
Lot 2	3185.37	3231.9	134.34	97.78	3140.48	3283.3	136.22	95.65
Total	6168.75	6308.8	262.30		6178.55	6380.5	256.37	
Average				97.78 96.83				96.83
	In favor of Timothy.....			.95	In favor of Prairie Hay			.58

It appears from the above summary that it required .95 of a pound more of dry matter to produce one hundred pounds of milk when prairie hay was fed than it did with timothy hay, and that it required .58 of a pound of dry matter less to produce a pound of butter fat when prairie hay was fed than it did with timothy. The difference is so slight that it confirms the general conclusion that the two kinds of hay have equal feeding value.

HERD RECORD FOR 1895.

So many changes took place in the station dairy herd during the year 1895 that the number which remained during the whole year is quite small. It is the aim to account for every animal that comes into the herd and to publish the record of all the cows that remain during one period of lactation. Not all of the records can be used in calculating cost of production or in forming groups based on conformation. It is found that immature cows cannot be used in making comparisons in cost of butter production, because the growing heifer always uses part of the nutriment in the feed in building the body. It sometimes happens that a cow in her prime does very unsatisfactory work during a whole period of lactation, simply because she did not start under favorable or normal conditions. Old cows with defective udders, impaired digestion or unsound teeth cannot be used when careful work is intended. But if an old cow is sound she can do as good work when twelve years old as she could when younger. A cow's annual yield will vary, because of the different conditions which exist from year to year. Again, a cow may be temporarily out of condition sometime during her period of lactation and thus fail to do an average year's work. Some are very sensitive and when under the care of a gruff or careless and indifferent attendant or milker will not do normal work. There are numerous instances where whole herds of selected dairy cows, representing the finest breeding and individually well adapted for dairy work, have proven a failure both as breeders and milk and butter producers simply because they were kept with and handled by attendants who had been

accustomed to the care of beef cattle and who gave the sensitive dairy cow the same *kind* of treatment that they were in the habit of giving the beef animals. So it follows that there will always be a considerable diversity of opinion in regard to the merits of different breeds and types of cattle, even where the opinions are based upon actual experience and demonstration.

It has been the purpose from the establishment of the herd to so handle the cows that they will give the greatest amount of dairy products for the maximum time at the minimum cost. With this object in view neither the herd nor a single member of the herd can be fed above a fair average ration for even a week, for by so doing her future usefulness would be in peril and the time of her dairy work shortened.

Sometimes it becomes desirable or necessary to feed cows kept at an experiment station a kind of food that is more expensive than another having equal or greater feeding value, and in such cases cost of producing dairy products is greater. Such was the case during the first four months in the year when a considerable portion of the ration was wheat.

The Herd.—The number of cows working in the herd the whole of the year was thirteen. Of these Belle, Countess, Lou, Lydia and Quidee were purchased in the autumn of 1894; Beckley 2d, Reddie 2d and Tricksey 2d were heifers with first calf and had been reared on the University farm; Ethel, Houston, Sweet Briar and Topsy were in the herd the year previous. Allie, Pride and Nora were with the herd, but their record cannot be included, as they were not under normal conditions. Allie was slaughtered for beef and Nora and Pride were out of condition for some considerable time. Patsy was sold for a family cow and Bettie and Dora died of milk fever. This accounts for all the cows.

The following is a list of the cows, their breeding, days in milk and yield of milk and butter fat:

TABLE LIV.—Total Individual Yields of Milk and Butter Fat.

NAME	BREED	Days in Milk	Lbs. of Milk	Lbs. of Butter Fat
Beckley 2d.....	Grade Jersey.....	365	4794.4	262.65
Belle.....	Grade Shorthorn.....	304	5762.9	243.91
Countess.....	Holstein.....	318	11736.6	295.05
Ethel.....	Grade Shorthorn.....	239	5149.4	207.05
Houston.....	Jersey-Guernsey.....	306	6700.7	346.65
Lou.....	Grade Holstein.....	330	9226.8	331.79
Lydia.....	Swiss.....	302	7131.2	256.13
Olive.....	Grade Guernsey.....	316	6748.1	276.94
Quidee 2d.....	Holstein.....	331	7645.1	266.75
Reddie 2d.....	Grade Guernsey.....	329	5115.0	260.30
Sweet Briar.....	Guernsey.....	340	8426.7	419.93
Topsy.....	Grade Holstein.....	330	12524.8	474.96
Tricksey 2d.....	Guernsey.....	329	5480.2	287.49
Average.....		317	7418.6	302.28

As in former years each milking was weighed and tested by the Babcock test for per cent. of butter fat. The yield of milk and butter fat of each individual and of the herd is believed to be about normal work, except that Sweet Briar exceeded her normal yearly yield by from fifty to seventy-five pounds.

The heifers Beckley 2d, Quidee 2d, Reddie 2d and Tricksey 2d gave on an average 269 pounds of butter fat, which is equivalent to 314 pounds of butter.

The largest yield of both milk and butter fat is by the grade Holstein Topsy, making the third consecutive year that she leads the herd in quantity of milk and butter fat. The next largest yield of milk was by the registered Holstein "The Countess," giving 11,736 pounds, but in yield of butter fat she stood fifth, Sweet Briar ranking second, Houston third and Lou fourth. The yield for the herd both in pounds of milk and butter fat is the best that it has made. The next largest yield was in 1893, when it averaged 300.9 pounds of butter fat and 6,407 pounds milk per cow. In 1895 the cows averaged in round numbers 1,000 pounds more milk than in 1893; but they averaged only 1.3 pounds more of butter fat. The great discrepancy between

the yield of milk and butter fat is caused by the introduction into the herd of three additional Holsteins and a Swiss cow; all giving a large quantity of milk, but rather light in fat content.

THE COWS.

Beckley 2d.—A high grade Jersey, dam Beckley, sire a full blood Jersey. Dropped November 12, 1892. She was raised on whole milk, and by spring, 1893, when turned out to pasture, was very fat. Her dam, during the two years that she was in the herd, gave on an average 369 pounds of butter per year. She was a good feeder, but carried considerable flesh. She is illustrated in Bulletin 35 representing "Group II.—Cows Having a Well Defined Tendency to Lay on Flesh." Beckley 2d was always fat, having inherited the tendency in some measure from her dam and she also acquired the habit by being fed liberally on whole milk during the first few months. She came in the 8th of September, 1894, and was in her fourth month of lactation when the record begins. This places her at a disadvantage when compared with cows that came in later in the season. By examining the table giving dry matter required to produce a pound of butter fat by group I. in the experiment comparing timothy with prairie hay, it will be seen that she required a pound more than did Tricksey that came in a month later. At the time of the experiment she had been in milk a little over two months. The weak point, from a dairyman's standard, with cows having a flesh-forming tendency, is the rapid increase in cost of dairy products as the period of lactation advances.

Belle.—Roan grade shorthorn, about 8 years old, had been used in the city as a family cow and came into the herd the 8th of January. She was a fair specimen of a good milking shorthorn, being of good depth through the middle and

having only a moderate tendency to growing flesh. She was just medium in thickness of shoulder, neck and thigh and in general conformation resembled Beckley illustrated in Bulletin 35, page 59.

Countess.—Holstein-Friesian, dropped March 12, 1884, and entered in Vol. 1 Holstein-Friesian Herd Book as No. 668. She is the largest cow in the herd, but is not so good a feeder as her size would indicate; carries just a medium amount of flesh for a Holstein; has a fine udder both as to size and form; veins very prominent on udder; milk veins large and tortuous; medium in thickness through the shoulder; broad loin and very broad between hook points and pin bones; coat exceedingly fine.

Ethel.—Roan grade shorthorn, about four years old; rather short heavy neck; thick through shoulders and high on rump; body cylindrical and level top and bottom line, hook points well rounded and thighs well filled; excellent udder development, extending out on belly almost on a horizontal line and extending almost to the vulva when fresh in milk.

Houston.—A cross-bred Channel Island cow, dam a Jersey, sire a Guernsey. Just medium in size, and weighing on an average 900 pounds; spare in head, neck, shoulders and hind-quarters; carried a large middle piece in proportion to her size; narrow across the back and short from hook points to pin bones, which gave her exceedingly small and light hind-quarters. Her udder was rather of an inferior order, being only medium in size, and the line of attachment to the body rather short. While her conformation and performance show that a cow falling far short of what is generally considered a good udder can be a large and very economical producer, it does not follow that she would not have been a better cow had she carried one large and well formed. Her feeding capacity was about 25 pounds of dry matter per day, making about 28 pounds per 1,000 pounds live weight. Her disposition was good, and under good care

and satisfactory surroundings slow to anger, but vicious when aroused.

Lou.—High grade Holstein, about 7 years old; large; rather deep in body and full in thigh; rather thick through the shoulder; back and hip points well rounded out; thighs rather full; coat short, coarse and glossy; a fine specimen of a strong, vigorous, well bred, useful animal; large udder, and of good form. Her teats were well placed, but had the objectionable cone shape. She was not nearly as large framed as Countess, but weighed nearly as much.

Lydia.—Full blood Brown Swiss, registered in the Herd Book as Sida No. 799 and dropped February 14, 1891. She was in her fifth year, large and vigorous and weighed about 1,150 pounds in ordinary working condition. The two most noticeable points were her stockiness and cylindrical form. Skin rather thick and yellow; hair coarse; udder rather small for size of cow and teats good size and well placed. She was sluggish in movement, apparently indifferent to her surroundings so long as her wants were supplied.

Olive.—Grade Guernsey, 11 years old; medium size in frame; light in middle piece and spare; weight about 800 pounds, dull expression and slow in movement. Her udder is small and covered with long, coarse hair, but gives more milk than its appearance would indicate. She is a light feeder, taking about 20 pounds of dry matter per day. Her milk is very yellow in color, but is not so rich as is the milk from some of the other cows. Skin thick and coat harsh and coarse.

Quidee.—Holstein-Friesian, in her third year and with first calf; quite fine in bone, but large frame; fine glossy coat; medium fine hair; long, spare and light in body; udder a little meaty; square, large, well formed forequarters and fair hind-quarters. She made quite rapid growth during the year; quiet and rather slow.

Reddie 2d.—Grade Guernsey, about 27 months old when the year's record began. Good size for a heifer of her age, carrying three-quarters Channel Island blood. Good depth of middle, with only a slight tendency to smoothness. Udder medium in size, good form, teats good size and well placed. Color of milk very yellow. Rather quick in motion.

Sweet Briar.—Registered Guernsey, 11 years old; large, stately in appearance, high spirited and quick tempered; very full, expressive and quick eye; beautiful lemon fawn coat, dappled; fine, glossy short hair; udder small, covered with fine, short hair and attachment to body short; teats long, well placed and in good form; body very deep, but quarters and back just a little rounded. She is exceedingly notional as to her environment, and if not handled with consideration and good judgment when fresh in milk her year's work can be spoiled in a short time.

Topsy.—Grade Holstein; large; carries only a moderate amount of flesh; thighs and shoulders light for a Holstein; coat rather short, glossy and medium fine; quiet and contented disposition in any place if furnished with enough good food; large udder, well formed, good sized teats squarely placed; large milk veins, tortuous and leading to three orifices on each side. She is a good feeder, taking from 30 to 32 pounds of dry matter daily, which is at the rate of 27 to 28 pounds per 1,000 pounds live weight.

Tricksey 2d.—Registered Guernsey, 2 years old; medium light in bone, thin skin, fine hair, light neck and shoulders; thin thighs and only medium depth through the middle of the body; open, quick bright eyes; quick in action and possessing unusual intelligence.

Feeding and Management.—The herd was confined in a basement barn during the winter, being kept in their stalls except a few hours in the middle of the day,—generally from 10 in the forenoon until 3 in the afternoon,—when they were turned into a covered runway during cold weather, and

when it was mild they were left in the yard an hour or two. No feed was given them while in the runway, but they had access to water and salt.

From the 19th of November, 1894, to the 11th of February, 1895, the herd was working in two groups, one taking a ration composed of 10 pounds of roots, 16 of timothy hay and 14 of grain, the grain mixture being composed of 6 parts bran, 7 parts wheat and 1 part oil meal, while the other group took the same amount of hay, roots and grain, but the grain ration was a mixture composed of 6 parts bran, 4 parts barley, 3 parts corn and 1 part oil meal. Each cow received as much of the grain mixture as she would take clean in addition to the hay and roots and they were fed the two rations in alternate periods of three weeks.

The table on following page gives the composition of the feed stuffs fed to the herd from the first of the year until it was turned out to pasture.

The composition of bran, corn, wheat, oil meal, ensilage, prairie and timothy hay was obtained by analyses made by Prof. Snyder from samples of the feeds used. The figures given on timothy are averages of six samples and those on prairie hay are averages of four samples taken at intervals between February 6th and April 7th. The composition of the cotton-seed meal and all the figures on digestibility of the feeds are taken from Bulletin 36, Minnesota Station.

The cows were fed twice a day except when given ensilage or roots, which they received at 2 p. m. The grain was fed first and while they were eating it they were milked. After milking they received hay. Slight changes were made in the quantity assigned to each animal as circumstances seemed to require, but they were made only at the beginning of the week or period. All rations were actually weighed out to each cow twice a day with scales carefully tested and adjusted at the beginning of the experiment. Every milking was weighed and tested with the Babcock test.

Composition of Food Stuffs Used.

FOOD.	PERCENTAGE COMPOSITION						DIGESTIBLE			
	Water	Dry Matter	Ash	Protein	Fiber	Nitrogen Free Extract	Ether Extract	Protein	C.-H.	Fat
Bran.....	9.00	91.00	4.02	14.00	8.90	53.78	6.30	12.5	42.1	3.6
Corn.....	9.77	90.23	1.77	9.58	1.85	72.83	4.20	9.2	68.5	3.1
Wheat.....	10.95	89.05	2.20	14.18	2.83	67.67	2.17	11.0	58.6	1.5
Oil Meal.....	8.55	91.45	5.63	37.91	9.69	30.30	7.92	83.7	29.0	7.0
Cottonseed Meal.....	8.14	91.86	7.95	44.38	5.61	22.71	11.20	82.0	20.2	10.0
Basilege.....	75.41	24.59	1.39	2.14	5.04	15.35	.67	1.2	15.0	.6
Prairie Hay.....	11.98	88.02	6.57	5.65	30.44	41.85	2.74	3.5	41.8	1.4
Timothy Hay.....	11.73	88.27	5.23	5.90	31.04	44.49	2.61	3.4	43.4	1.3
Beets.....	85.00	15.00						1.5	9.0	1.0

The stock foreman personally weighs out to each animal the feed it is to have each day in the week and makes a weekly report of the amount and kind of feed given. He also makes a daily written report to the chief of the division, noting carefully all incidents that come under his observation bearing upon each animal in the herd.

A strict routine is observed in all the work. Feeding and milking are done at exactly the same time each day. The cows are milked quickly, but gently, and in regular order. There are generally some cows in a herd that manifest a desire to be milked first. Some even will begin to lose their milk if they are not first, and the order in which the cows are milked is always adjusted to these individual peculiarities. All animals are treated with kindness and no loud talking or rough handling is permitted.

No such thing as a kicking cow or heifer is known in the herd. Heifers soon to come in are handled with great kindness and their udders manipulated to get them accustomed to being milked and they show as great satisfaction in being milked the first time as do older members of the herd. Heifers are bred to come in in the fall except in cases where there is a tendency to lay on flesh, in which case they are bred as soon as this is noticed. If a heifer or cow drops her calf in the spring she is not bred until the December following so that she will drop her second calf in the fall. During the first few years after the herd was established the calves and yearling heifers were fed some grain and in the majority of cases they showed a tendency to get smooth and fleshy before they came in and were not as promising cows as were their dams. Now calves and young heifers get no grain until they come into profit except the small allowance of ground flax they receive from the time they are three weeks old until weaned. Heifers with first calf get from six to eight pounds of grain per day. Mature cows receive from ten to fourteen pounds of grain and coarse feed, according to their capacity.

The following ration fed to some cows will show about how the rations are adjusted to the feeding capacity of different cows:

TABLE LV.—Sweet Briar's Ration.

FOOD.	Lbs.	D. M.	DIGESTIBLE			Cost, Cents
			Pro.	C.-H.	Fat	
Bran.....	6	5.46	.75	2.52	.21	3.30
Barley.....	4	3.63	.35	2.47	.07	2.80
Corn.....	3	2.70	.28	2.05	.09	2.10
Oil Meal.....	1	.94	.27	.38	.06	1.30
Timothy.....	16	14.12	.54	6.94	.20	4.50
Beets.....	10	1.35	.11	1.02	.01	1.00
		28.20	2.30	15.38	.64	15.00

Total digestible nutrients 18.32

A cow having the feeding capacity of Sweet Briar received a ration containing 28.2 pounds of organic matter which contains of digestible protein 2.3 pounds, digestible carbohydrates 15.38 pounds and .64 of a pound of digestible fat, the ration costing 15 cents.

A cow that would take only 10 pounds of the grain mixture would receive the following ration, containing 10 pounds of grain, 12 of hay and 5 of roots:

TABLE LVI.—Bettie's Ration.

FOOD.	Lbs.	D. M.	DIGESTIBLE			Cost, Cents
			Pro.	C.-H.	Fat	
Bran.....	4.29	3.90	.53	1.80	.15	2.3
Barley.....	2.86	2.59	.25	1.76	.05	2.0
Corn.....	2.14	1.93	.20	1.47	.06	1.6
Oil Meal.....	.71	.67	.19	.27	.04	1.9
Timothy.....	12.	10.59	.41	5.20	.15	3.3
Beets.....	5.	.67	.05	.51	.01	.5
		20.35	1.63	11.01	.46	10.6

Total digestible nutrients 13.1

While the Guernsey Bettie received only 13 to 14 pounds of digestible matter per day, it was as large for her as was the one fed to the Guernsey Sweet Briar that contained 18.3 pounds of digestible matter. These are some of the rations fed during the month of January. Later the cows had a ration containing ensilage, timothy and prairie hay. To show how these rations were compounded and the amount of organic and digestible matter they contained a few tabulated rations are given.

TABLE LVII.—Houston's Ration when Prairie Hay and Ensilage were Fed.

FOOD.	Pounds	D. M.	DIGESTIBLE		
			Pro.	C. H.	Fat
Bran.....	5.14	4.68	.64	2.16	.19
Corn.....	1.72	1.55	.16	1.18	.05
Wheat.....	4.28	3.81	.47	2.51	.06
Cotton Seed Meal.....	.86	.79	.28	.17	.09
Ensilage.....	12.	2.95	.14	1.80	.07
Prairie Hay.....	13.	11.44	.46	5.43	.18
Per 1000 lbs. Live Weight..	.....	25.22	2.15	13.25	.64
	.....	27.77	2.37	14.59	.70

TABLE LVIII.—Houston's Ration when Timothy and Ensilage were Fed.

FOOD.	Pounds	D. M.	DIGESTIBLE		
			Pro.	C. H.	Fat
Bran.....	5.14	4.68	.64	2.16	.19
Corn.....	1.72	1.55	.16	1.18	.05
Wheat.....	4.28	3.81	.47	2.51	.06
Cotton Seed Meal.....	.86	.79	.28	.17	.09
Ensilage.....	12.	2.95	.14	1.80	.07
Timothy.....	13.	11.48	.44	5.64	.17
Per 1000 lbs. Live Weight..	.....	25.26	2.13	13.46	.63
	.....	27.82	2.34	14.82	.69

TABLE LIX.—Topsy's Ration when Timothy was Fed.

FOOD.	Pounds	D. M.	DIGESTIBLE		
			Pro.	C. H.	Fat
Bran.....	6	5.46	.75	2.53	.22
Corn.....	2	1.80	.18	1.37	.06
Wheat.....	5	4.45	.55	2.93	.08
Cotton Seed Meal.....	1	.92	.32	.20	.10
Ensilage.....	14	3.44	.17	2.10	.08
Timothy.....	18	15.89	.61	7.81	.23
Per 1000 lbs. Live Weight..		31.96 27.74	2.58 2.24	16.90 14.72	.77 .67

TABLE LX.—Lydia's Ration when Grain, Ensilage and Prairie Hay were Fed.

FOOD.	Pounds	D. M.	DIGESTIBLE		
			Pro.	C. H.	Fat
Bran.....	5.14	4.68	.64	2.16	.19
Corn.....	1.72	1.55	.16	1.18	.05
Wheat.....	4.28	3.81	.47	2.51	.06
Cotton Seed Meal.....	.86	.79	.28	.17	.09
Ensilage.....	12.00	2.95	.14	1.80	.07
Prairie Hay.....	16.00	14.08	.56	6.69	.22
Per 1000 lbs. Live Weight..		27.86 25.33	2.25 2.05	14.51 13.19	.68 .62

The tables give the actual total dry matter and digestible nutrients consumed by the different cows per day; also the amount they took per 1,000 pounds live weight. The standard ration for a dairy cow weighing 1,000 pounds is generally fixed at 24 pounds dry matter, containing 15.4 pounds digestible nutrients, of which 2.5 are protein, 12.5 carbohydrates and .4 pounds of fat. In practical feeding, however, little attention can be given to this, since it is found that some heavy cows are comparatively light feeders and some light cows are heavy feeders. This is shown by the following table giving the amount of dry matter eaten daily by the cows from March 11th to 24th inclusive, and how much it was per 1,000 pounds live weight. Incidental-

ly is given the calculated digestible nutrients contained in the ration with the average daily yield of milk and butter fat.

TABLE LXI.—Giving Dry Matter Actually Consumed, and Rate Per Thousand Pounds Live Weight.

NAME.	Dry Matter per 1000 lw	D. M.	DIGESTIBLE			AV. DAILY YIELD	
			Pro.	C. H.	Fat	Milk	Butter Fat
Beckley 2.....	24.38	21.16	1.68	11.22	.50	13.17	.73
Countess.....	24.47	28.80	2.36	15.36	.70	43.55	1.03
Houston.....	27.82	25.26	2.13	13.46	.63	25.99	1.38
Lou.....	24.84	27.02	2.20	14.33	.66	33.58	1.20
Olive.....	26.68	21.13	1.69	11.02	.52	21.66	.93
Reddie.....	27.14	20.63	1.66	10.82	.50	15.25	.78
Belle.....	21.48	20.47	1.76	10.76	.68	19.73	.83
Lydia.....	25.15	27.42	2.23	14.30	.68	27.90	1.01
Quidee.....	26.72	22.82	1.87	11.95	.55	27.05	.96
Sweet Briar.....	26.38	26.98	2.22	14.09	.67	25.80	1.37
Topsey.....	27.75	31.91	2.60	16.65	.79	40.04	1.54
Tricksey.....	26.17	18.83	1.51	9.85	.46	16.02	.87
Total.....		292.53	23.91	153.91	7.16	309.74	12.63
Average.....		24.38	1.99	12.82	.59	25.81	1.05

In adjusting the ration for each cow her feeding capacity only was taken into account. Had they been fed according to weight many of the cows would have gone hungry while others would have received more than they could eat.

The charge for pasture was 25 cents a week for cows that took a standard ration during the winter; those that required more or less than the standard ration, which was 14 pounds of grain, 8 of hay and 20 of ensilage, were charged the same proportionally for pasture to their winter feed to the standard ration.

Summer Feeding.—The cows were turned into pasture on the morning of May 6th. The grass was pretty well advanced and had made sufficient growth to receive the herd several days earlier; but such changes are made only at the beginning of the week

From the time they were turned into pasture until the 12th of August they received from 2 to 4 pounds of grain and as much hay as they would eat per day, except that from the 8th of July to the 12th of August they received from 10 to 20 pounds of oat hay. By this is not meant that a cow was fed from 10 to 20 pounds, but that the lightest feed given to any cow was 10 pounds while the most that was given was 20 pounds. A cow that was fed 10 pounds per day one week received the same the week following, unless she showed by not cleaning the manger completely that she was receiving too much. From the 12th of August until the 7th of October the grain ration was simply bran, from 4 to 10 pounds, and corn fodder and hay for roughage. From the 7th of October to the 24th of November the grain ration was composed of bran, barley, oats, peas, gluten and germ meal. This was done to clear the feed bins of little odds and ends that had accumulated. The winter's feed was then purchased at the following prices:

Prairie hay, per ton.....	\$3.00
Bran, per ton.....	6.50
Barley, per bushel.....	.16
Oats, per bushel	.14
Linseed meal, per ton.....	14.00

From the 25th of November to the close of the year the grain ration was composed of 6 parts bran, 4 parts barley, 3 parts oats and 1 part linseed meal. A full ration contained 14 pounds of grain mixture, 8 pounds of prairie hay and 20 pounds of ensilage. The ensilage was valued according to the per cent. of dry matter it contained. That fed up to the close of the year contained 14.85 per cent. and was rated at \$1 per ton.

TABLE LXII.—Composition of One Hundred Pounds of the Feed Stuffs Used.

FOOD.	Dry Matter	DIGESTIBLE			Price Per ton or bu.
		Protein	C.-H.	Fat	
Bran.....	89.49	13.80	40.44	3.98	\$ 6.50
Barley.....	92.24	11.00	60.58	1.37	.16
Oats.....	92.75	9.76	51.40	3.43	.14
Linseed Meal.....	91.45	33.74	29.06	7.05	14.00
Upland Prairie Hay.....	85.44	4.25	39.08	1.58	3.00
Bottomland Prairie Hay.....	82.94	4.25	39.08	1.19	3.00
Ensilage 1st Silo.....	14.85	.95	8.11	.49	1.00

This table gives the composition of the feed during the winter. None of the bottomland prairie or timothy was fed until after the close of the year.

DAIRY PRODUCTS.

In all our work the Monday nearest the 1st of January is the beginning of the dairy year, which is divided into 13 periods of four weeks each. The object is to have each period the same length, which would not be the case if the year were divided into 12 periods, each a calendar month. For convenience the date covered by each period is stated at the head of the column. It is not deemed necessary to call attention to any particular table or part of a table; neither do they need any explanation, save possibly the statement that all animals in the Dairy Division are weighed every Monday and from these weekly weights the averages for the periods and the year are calculated.

TABLE LXIII.—Milk Yield of Each Cow for Each Period of Four Weeks and Total for Year 1895.

NAME	Dec. 31 to Jan. 27	Jan. 28 to Feb. 24	Feb. 25 to March 24	March 25 to April 21	April 22 to May 19	May 20 to June 16	June 17 to July 14	July 15 to Aug. 11	Aug. 12 to Sept. 8	Sept. 9 to Oct. 6	Oct. 7 to Nov. 3	Nov. 4 to Dec. 1	Dec. 2 to Dec. 29	Total
Beckley 2.....	368.9	393.8	377.3	353.9	387.3	418.8	406.3	459.1	415.4	353.1	303.2	289.9	287.4	4794.4
Belle.....	363.2	514.3	549.3	522.2	606.6	590.1	518.2	401.7	303.9	104.9	.....	486.5	1502.4	5762.9
Countess.....	1240.2	1222.6	1194.9	1133.3	1156.9	1204.2	953.1	551.7	229.9	195.6	.....	1327.9	1502.4	11786.6
Ethel.....	.....	204.2	785.4	749.6	744.9	743.1	676.6	519.2	339.0	108.5	.....	278.9	.....	5149.4
Houston.....	685.2	659.8	706.4	683.8	708.2	702.4	573.9	407.5	367.6	164.0	.....	49.9	991.0	6700.7
Loa.....	1077.2	992.3	938.6	790.6	840.8	967.6	798.7	470.0	221.8	43.7	277.8	920.5	832.2	9226.8
Lydia.....	905.9	879.5	811.6	728.2	877.4	700.1	655.1	488.9	369.6	162.2	.....	.....	752.7	7131.2
Olive.....	752.6	636.8	611.4	555.9	612.3	611.2	494.5	391.9	228.9	.....	218.5	827.8	806.3	6748.1
Quidde.....	688.9	711.9	739.4	692.7	744.4	809.1	639.2	480.9	120.2	90.1	696.0	590.6	861.7	7645.1
Keddle 2.....	500.2	450.0	416.0	388.6	421.5	448.9	426.2	372.6	200.5	16.1	365.2	567.4	540.9	5115.0
Sweet Briar.....	834.8	778.1	733.9	719.1	760.9	812.6	690.6	569.9	232.9	11.5	766.6	773.9	751.9	8426.7
Topay.....	1242.6	1232.1	1149.2	1040.9	1164.8	1234.3	1058.7	683.5	243.1	80.3	1102.8	1100.8	1218.3	12524.8
Trickey 2.....	481.8	454.8	438.9	429.9	475.9	545.8	493.6	385.8	203.4	.....	455.0	550.6	591.7	5480.2

TABLE LXIV.—Butter From each Cow for Each Period of Four Weeks and Total for the Year 1895.

NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Beckley 2.....	25.18	26.15	24.70	22.33	24.78	25.79	26.93	27.99	24.73	23.12	18.72	19.06	18.95	306.43
Belle.....	77.78	26.47	26.29	25.55	28.50	29.38	26.33	27.27	18.10	6.20	.....	20.70	28.31	284.53
Countess.....	36.64	36.98	36.48	34.59	33.59	31.18	28.73	27.08	17.12	5.90	.....	39.62	43.34	344.23
Ethel.....	45.24	45.98	46.49	46.20	47.02	47.19	39.03	38.07	24.55	10.63	.....	22.22	18.31	261.36
Houston.....	33.86	35.98	33.99	33.89	32.70	31.03	30.96	28.72	24.55	10.63	.....	22.22	18.31	261.36
Loa.....	33.86	35.98	33.99	33.89	32.70	31.03	30.96	28.72	24.55	10.63	.....	22.22	18.31	261.36
Lydia.....	33.86	35.98	33.99	33.89	32.70	31.03	30.96	28.72	24.55	10.63	.....	22.22	18.31	261.36
Olive.....	33.86	35.98	33.99	33.89	32.70	31.03	30.96	28.72	24.55	10.63	.....	22.22	18.31	261.36
Quidde.....	28.09	30.98	30.80	28.05	29.24	28.63	24.18	19.55	4.89	.....	10.46	38.50	30.79	328.92
Keddle 2.....	25.01	26.22	26.11	24.14	26.70	26.28	26.85	24.61	15.90	1.82	19.58	21.26	27.39	311.21
Sweet Briar.....	48.69	49.77	46.41	42.14	44.36	42.68	39.71	34.78	15.70	5.19	41.04	42.09	42.04	489.92
Topay.....	38.24	39.24	38.24	36.99	39.45	31.31	27.86	31.74	13.74	.....	51.70	48.25	55.41	554.13
Trickey 2.....	38.24	39.24	38.24	36.99	39.45	31.31	27.86	31.74	13.74	.....	24.06	31.98	35.14	385.41

TABLE LXV.—Average Per Cent. Fat in Milk of Each Cow for Each Period and for the Year 1895.

NAME.	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Beckley 2.....	5.85	5.69	5.61	5.41	5.48	5.28	5.68	5.23	5.10	5.60	5.29	5.64	5.43	5.48
Belle.....	4.20	4.41	4.19	4.10	4.03	4.27	4.36	4.79	5.19	5.71	.....	3.65	3.76	4.23
Countess.....	2.46	2.56	2.53	2.62	2.49	2.26	2.54	2.65	3.03	2.21	.....	2.56	2.47	2.51
Ethel.....	4.77	4.31	4.02	3.76	3.68	3.65	3.74	3.98	4.54	4.54	.....	.....	4.25	4.02
Houston.....	5.80	6.71	6.52	5.13	5.08	4.53	5.38	5.27	5.68	5.55	.....	3.81	4.51	5.17
Lou.....	3.47	3.91	3.71	3.67	3.56	3.32	3.52	3.78	3.68	4.53	4.44	3.98	3.42	3.60
Lydia.....	3.43	3.51	3.51	3.51	3.60	3.39	3.76	3.90	3.99	4.39	.....	.....	3.92	3.59
Olive.....	8.66	4.32	4.22	4.78	4.08	3.75	4.46	4.76	4.93	.....	4.18	3.99	3.70	4.10
Quidde.....	3.50	3.72	3.51	3.47	3.37	3.03	3.24	3.64	3.49	3.96	3.88	3.52	3.55	3.49
Reddie 2.....	4.29	5.00	5.16	5.34	5.43	5.01	5.40	5.66	6.80	9.69	4.59	4.74	4.76	5.09
Sweet Briar.....	5.00	5.48	5.42	5.02	5.00	4.50	4.98	5.32	5.78	3.83	4.59	4.66	4.79	4.98
Topsy.....	3.67	3.70	3.66	3.75	3.73	3.74	3.87	4.16	4.14	3.40	4.02	3.76	3.77	3.79
Tricksey 2.....	5.03	5.41	5.51	5.38	5.30	4.92	5.15	5.70	6.77	.....	4.50	4.94	5.36	5.25

TABLE LXVI.—Average Weight of Each Cow for Each Period and for the Year 1895.

NAME.	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Beckley 2.....	832	850	842	865	864	888	873	875	888	891	890	936	962	881
Belle.....	940	933	946	962	949	959	992	1036	1052	1084	1070	998	970	991
Countess.....	1178	1165	1192	1189	1167	1185	1236	1279	1296	1305	1315	1221	1178	1222
Ethel.....	1178	1174	1081	1085	1073	1074	1109	1125	1141	1165	1183	1254	1245	1145
Houston.....	932	917	909	903	885	878	898	949	980	994	1007	1050	948	942
Lou.....	1123	1112	1111	1092	1106	1148	1214	1278	1307	1367	1355	1245	1206	1206
Lydia.....	1048	1078	1081	1078	1075	1067	1064	1151	1172	1223	1269	1289	1217	1139
Olive.....	794	811	794	788	784	806	832	844	853	903	894	821	802	825
Quidde.....	832	870	886	871	863	888	950	994	1024	1040	943	961	965	930
Reddie 2.....	723	743	755	781	791	826	864	883	909	938	886	854	870	833
Sweet Briar.....	1070	1081	1078	1054	1060	1063	1072	1113	1154	1151	1056	1045	1055	1082
Topsy.....	1178	1150	1152	1148	1171	1165	1192	1267	1297	1328	1199	1178	1183	1201
Tricksey 2.....	742	742	744	744	774	796	837	878	894	912	847	838	832	814

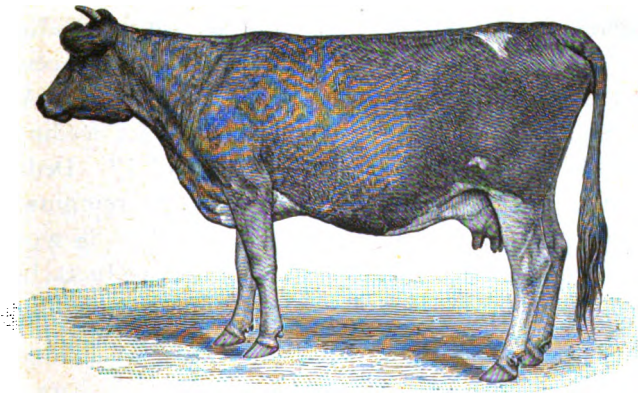
TABLE LXVII.—Giving Yield of Milk and Butter Fat and Cost for the Year 1895.

NAME.	Age	Cost of Feed.	Pounds of Milk.	Per cent. Fat.	Pounds of Fat.	Pounds of Butter.	Cost of 100 Pounds Milk.	Cost of 1 lb. of Butter Fat.	Cost of 1 lb. of Butter
Beckley 2d.....	3	\$25.19	4794.4	5.48	262.65	306.43	52.54	9.59	8.22
Belle.....	8	24.54	5762.9	4.23	243.91	284.56	42.58	10.06	8.62
Countess.....	10	33.84	11736.6	2.51	295.05	344.23	28.83	11.47	9.83
Ethel.....	5	25.21	5149.4	4.02	207.05	241.56	48.96	12.18	10.44
Houston.....	11	28.49	6700.7	5.17	346.65	404.43	42.52	8.22	7.04
Lou.....	8	30.32	9228.8	3.60	331.79	387.09	32.86	9.14	7.83
Lydia.....	5	32.79	7131.2	3.59	256.13	298.82	45.98	12.80	10.97
Olive.....	11	23.62	6748.1	4.10	276.94	323.10	35.00	8.53	7.31
Quidde.....	3	26.98	7645.1	3.49	266.75	311.21	35.29	10.11	8.67
Reddie 2d.....	3	24.37	5115.0	5.09	260.30	303.68	47.64	9.37	8.02
Sweet B.....	11	31.38	8426.7	4.98	419.93	489.92	37.24	7.47	6.41
Topsy.....	9	39.31	12524.8	3.79	474.96	554.12	31.39	8.28	7.09
Tricksey 2d.....	2	24.09	5480.2	5.25	287.49	335.41	43.96	8.38	7.18
Average.....	.....	\$28.47	7418.6	4.07	302.28	352.66	38.38	9.42	8.07

During the year 1895 the herd was composed of thirteen cows. They represented Shorthorns, Holsteins, Jerseys, Guernseys and Brown Swiss, and were of various ages, some with first calf, some in the prime of life and some very old. The range in cost for feed during the year was from \$24.09 for a 2-year-old heifer to \$39.31 for a grade Holstein. The average cost of maintaining a cow for the year was \$28.47. The yield of milk per cow ranged from 4,794 pounds from the high-grade Jersey Beckley 2d to 12,524 pounds from the grade Holstein Topsy, the average yield for the herd being 7,418 pounds. The fat content ranged from 2.51 to 5.48 and averaged 4.07. The lowest yield of butter was by the grade Shorthorn Ethel that gave 241.56; the next lowest yield was that of the grade Shorthorn Belle that gave 284.56; the third lowest the Swiss cow Lydia that gave 298.82. All the other members gave over 300 pounds, with Topsy's yield of 554.12 pounds as the highest in the herd. The cows averaged for the year 352.66 pounds of butter. The cost of producing a pound of butter ranged from 10.97 cents by the Swiss cow to 6.41 cents by the Guernsey Sweet Briar, and the average cost for the year was 8.07 cents.

Of the thirteen cows in the herd through the year there were five that could not be classed with either of the groups in studying the influence of type on cost of butter production. Of these, three were heifers with first calf that had made considerable growth during the year, which required food nutrients for purposes other than milk production. Countess was not assigned to either group because her record indicates that her digestion is impaired. Olive was a spare cow, but lacked depth of middle and was listed in group III. in Bulletin 35, being classed with spare cows lacking depth of body, and the cost of the food she ate during the year shows that she was a light feeder.

Dividing the remainder of the cows in the herd into two groups based on conformation their relative merits for the dairy becomes apparent.



GUERNSEY COW—SWEET BRIAR.

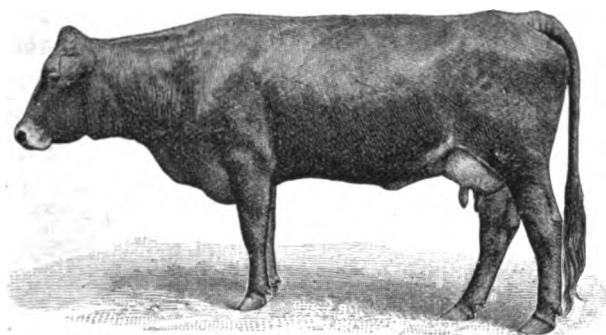
TABLE LXVIII.—Group I.—Cows Spare and Angular with Deep Bodies.

NAME.	Breed	Cost of Feed	Milk Lbs.	Cost of 100 Lbs. Milk	Butter Lbs.	Cost of 1 Lb. Butter Cts.
Houston.....	Jersey-Guernsey..	\$28.49	6700.7	42.52	404.43	7.04
Sweet Briar.....	Guernsey.....	31.38	8426.7	37.24	489.92	6.41
Topsy.....	Grade Holstein...	39.31	12524.8	31.39	554.12	7.09
Tricksey 2d.....	Guernsey.....	24.09	5480.2	24.09	335.41	7.18
		\$30.82	8283.1	37.20	445.97	6.91

The range of cost for feed during the year for group I. was from \$24.09 for Tricksey 2d to \$39.31 for Topsy, and the average cost was \$30.82. The yield of butter ranged from 335.41 to 554.12 pounds and averaged 445.97 pounds; the cow giving the smallest yield eating the least food and the cow giving the greatest yield eating the most food. The cost to produce a pound of butter ranged from 6.41 cents to 7.18 cents and averaged for the group 6.91 cents.

During the early part of the year Houston was troubled with the mange and a swelling on the jaw, which caused her to eat with great difficulty for several weeks; it was finally lanced and she recovered slowly. This incident, it is believed, caused her to yield less butter and at greater cost. With the exception of this year she always produced butter at less cost than any other member of the herd.

The cows in group I. produced 1,783.88 pounds of butter, and crediting them with the average net return realized by farmers for butter during the year, which was 15 cents per pound, their butter product amounted to \$267.58. Adding to this \$43.48, the value of the skim milk for feeding purposes, there is a gross return per cow of \$77.77. Deducting \$30.82, the average cost of the feed, there remains a net return per cow of \$46.95. Group I. ate \$123.28 worth of feed and produced \$311.06 worth of dairy products, being a return of \$2.52 for every dollar's worth of feed consumed.



SWISS COW—LYDIA

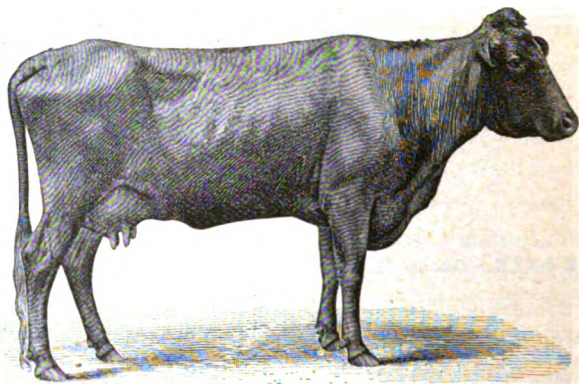
TABLE LXIX.—Group II.—Cows Having a Tendency to Lay on Flesh.

NAME.	Breed	Cost of Feed	Milk Lbs.	Cost of 100 Lbs. Milk	Butter Lbs.	Cost of 1 Lb. Butter Cts.
Belle.....	Grade Shorthorn	\$24.54	5762.9	42.58	284.56	8.62
Ethel.....	Grade Shorthorn	25.21	5149.4	48.96	241.56	10.44
Lou.....	Grade Holstein...	30.32	9226.8	32.86	387.09	7.83
Lydia.....	Swiss	32.79	7131.2	45.98	298.82	10.97
		\$28.21	6817.6	41.38	303.01	9.31

Of the cows in this group only Ethel showed a strong heredity for fattening. Belle, Lydia and Lou were less inclined that way or to carry much flesh, and would be considered good cows in the general acceptance of the term. Lou and Lydia were bred in dairy lines, but could not be classed with the spare cows having deep bodies, for reasons stated. Lydia made considerable gain in weight during the year. Her average weight for the first four weeks was 1,048, and during the last four it was 1,217.

The annual cost for feed for the cows in group II. ranged from \$24.54 to \$32.79 and averaged \$28.21. The average yield of milk was 6,817.6 pounds and the yield of butter ranged from 241.56 pounds to 387.09 and averaged 303 pounds. The cost for feed to produce a pound of butter ranged from 7.8 cents to 10.9 cents and averaged 9.3 cents.

The four cows in group II. produced 1,212 pounds of butter during the year, which at 15 cents a pound amounted to \$181.80. Adding \$35.79, the value of the skim milk for feeding purposes, gives a gross return of \$104.73, or a net return per cow of \$26.19.



OLIVE.—Spare and Angular but Lacking in Depth of Body.

In Bulletin 35 the cows were divided into four groups based upon conformation. To the first were assigned those being blocky in form; to the second, those having a medium tendency to carrying surplus flesh; to the third, those being spare and angular in form but lacking in abdominal capacity. To the fourth group were assigned those being spare and angular in form with deep bodies.

In this Bulletin the spare, deep-bodied cows are designated as group I., while those blocky in form and those having a medium tendency to fleshiness are assigned to group II. Group III., cows spare but lacking in abdominal development is omitted, since Olive was the only cow in the herd that could be properly assigned to it. A careful examination of the conformation of the Swiss cow Lydia will show that she is a composite representative of groups I., II. and III., Bulletin 35—all having a light middle piece, as compared with the size of the quarters. Such animals have a high co-efficient of food of maintenance and are therefore not as economical producers as those having a large middle piece and relatively light quarters.

RECORD OF THE HERD FOR THE WINTER OF 1895-96.

During the latter part of the summer of 1895 it was found that more cows would be needed in the Station herd in dairy practice work in the School of Agriculture and for dairy products in the Dining Hall. On the 2d of September Berry, Dena, Fairy, Ida, Shorty and Sophie were added to the herd. Maud and Blossom came October 21st and Hope November 11th. All these showed a more or less infusion of Shorthorn blood in both color markings and general conformation. Those coming on the 2d of September were taken from a drove of some 80 head that had been purchased in southern Wisconsin by a dealer for the purpose of shipping them to the Elgin district. They were a "lot of good cows," taking the average as they are found among farmers. The six selected out of the drove were considered to be of the best, with the single exception of Shorty that was quite small for her age. Of these Berry, Shorty and Sophie were fresh in milk when they came. Ida dropped her calf September 9th; Fairy dropped hers on the 19th, and Dena's did not come until the last of December. Maud and Blossom were a pair of "good family cows." Hope was selected out of a carload lot that had been purchased especially for family cows in the Twin Cities. They were all in fair working condition—neither thin in flesh nor fat; were free from tuberculosis and otherwise sound so far as known. Their ages were not known, but from an examination before they were dehorned their ages were assumed to be as appears in the table.

On the 11th of November the whole herd was again tested with turberculin. Houston was declared tuberculous and Countess, Quidee and Tricksey 2d were pronounced suspicious. They were retained in the herd and treated the same as the other members.

The object in compiling the record of the herd for the winter separately was to ascertain the actual amount of feed consumed and milk and butter fat produced from the beginning of lactation in the fall until the cows were turned out to pasture, the cost of milk and butter production while the cows were in milk, and the amount of dry matter required by each cow and by the herd to produce a hundred pounds of milk and a pound of butter.

The following table gives a list of the cows, with age, date of calving and when bred:

NAME.	Age	Breeding.	Date of Calving.	Bred.
Beckley 2d.....	4	Grade Jersey.....	Aborted.....	Dec. 17, '95
Belle.....	8	Grade Shorthorn	Nov. 11, '95.....	Dec. 25, '95
Berry.....	5	Grade Shorthorn .....	.....	Dec. 22, '95
Countess.....	10	Holstein.....	Nov. 5, '95.....	Dec. 20, '95
Duchess.....	5	Jersey.....	Oct. 21, '95.....	Dec. 18, '95
Ethel.....	6	Grade Shorthorn.....	Dec. 21, '95.....	.....
Fairy.....	7	Grade Shorthorn.....	Sept. 20, '95.....	Mch. 16, '95
Fortune.....	10	Jersey.....	Dec. 17, '95.....	Feb. 4, '96
Houston.....	12	Jersey-Guernsey.....	Nov. 30, '95.....	.....
Ida.....	8	Grade Shorthorn.....	Sept. 9, '95.....	Feb. 28, '96
Lon.....	8	Grade Holstein.....	Oct. 27, '95.....	Dec. 17, '95
Lydia.....	5	Swiss.....	Dec. 9, '95.....	Jan. 26, '96
Maud.....	8	Grade Shorthorn.....	Nov. 8, '95.....	Jan. 19, '96
Olive.....	11	Grade Guernsey.....	Oct. 27, '95.....	Jan. 23, '96
Pride 3d.....	2	Jersey.....	Sept. 8, '95.....	Dec. 28, '95
Quidee.....	3	Holstein.....	Oct. 1, '95.....	Dec. 31, '95
Reddie 2d.....	3	Grade Guernsey.....	Oct. 16, '95.....	Feb. 23, '96
Shorty.....	4	Grade Shorthorn.....	.....	Dec. 29, '96
Sophie.....	8	Grade Shorthorn.....	.....	Jan. 24, '96
Sweet B.....	10	Guernsey.....	Oct. 5, '95.....	Jan. 13, '96
Topsy.....	9	Grade Holstein.....	Oct. 31, '95.....	Jan. 6, '96
Tricksey.....	3	Guernsey.....	Oct. 14, '95.....	Jan. 20, '96

Feed.—During the winter the roughage used was upland prairie hay to January 20th, when our supply became exhausted. From the 20th to the 25th of January, inclusive, timothy was fed. On the 25th a carload of prairie hay arrived and upon examination it was found to be bottomland hay of a sedge variety, long rough blades with no stems. It was of excellent quality, greatly relished by the cows, being eaten up clean. It was fed during the remainder of the winter. Silage 1 was fed to January 26th; January 27th–31st silage 2, and from and after February 1st silage 3 was fed.

The grain ration from November 24th was a mixture composed of 6 parts of bran, 4 of barley, 3 of oats and 1 of oil meal. Before the 24th of November some ground peas, gluten and germ meal were fed in lieu of oil meal.

Chemical analyses of the different feed stuffs were made early in the experiment and later on composite samples were analyzed. Each cow received all the feed she would eat up clean, but the ratio between the grain and the roughage was maintained. If it was found advisable to increase or decrease grain, the hay and ensilage were changed in the same proportion. It is generally supposed that cows will eat more than they can make use of. Such, however, has not always been our experience, if judicious and liberal feeding is properly inaugurated and continued without interruption through the year and through a series of years. The first year a cow may take more than she can make use of, but later she, as a rule, will not eat more than she needs. It should not be understood that cows are fed without regard to quantity. On the contrary, it is weighed out with great care, when she first comes into the herd; always beginning with several pounds below her estimated feeding capacity and very gradually increasing, keeping close watch as to her appetite and digestion. It takes time to teach a cow that she will receive more feed when she needs it and that there is no reason for her to eat more than she really wants, but she will learn it in the course of the year if strict regularity is maintained. Such a thing as a cow "going off her feed" in the Station herd has very seldom occurred during the past few years. A skillful feeder can quickly tell if at any time during her life-time an animal has been overfed. There is one such in the herd, but it occurred before she came to us. While the cows are fed all they will take it is not the intention to give them more than they will eat clean; and whenever there is the slightest evidence that the feed is not taken out of the corners of the box or mangers absolutely clean the ration is reduced to a point where none

will be left. Cows will not eat the same quantity each year. They have off years with reference to feed, and yield of milk, the percent. of fat and solids, not fat, are quite constant. They also have off months and weeks and days, and the observant feeder measures out his rations accordingly. Were we feeding simply for butter production it might, in some instances, be found advisable to feed less to cows that manifest a disposition to convert feed into meat, but the problem under consideration is to ascertain what the disposition of the cow is in this regard and the why. When it is shown that it uniformly costs more to produce dairy products from one style or type of cow than it does from another there must be some physiological reason for it; and in order to study what natural law makes one cow convert part of her feed into butter and part into meat, and by what law of her being she is compelled to eat more feed than her neighbor for the production of a pound of butter when she is not converting any of her feed into meat, we must permit her to follow her inherited tendencies, and it is for this reason that every cow has all the feed that she can make use of.

TABLE LXX.—Composition of Feed Used During the Winter of 1895-96 and Cost Per Ton or Bushel.

	Dry Matter	DIGESTIBLE			Price per Ton or Bushel
		Protein	Carbo-hydrates	Fat	
Bran.....	89.49	13.80	40.44	3.98	\$6.50
Barley.....	92.24	11.00	60.58	1.37	.16
Oats.....	92.75	9.76	51.40	3.43	.14
Oil Meal.....	91.45	33.74	29.08	7.05	14.00
Upland Prairie Hay.....	85.44	4.25	39.08	1.58	3.00
Lowland Prairie Hay.....	82.94	5.20	39.08	1.19	3.00
Ensilage 1.....	14.85	.95	8.11	.49	1.00
Ensilage 2.....	19.06	1.23	10.80	.32	1.25
Ensilage 3.....	24.04	1.49	13.24	.37	1.60
Timothy.....	82.94	4.30	40.29	1.21	3.00

TABLE LXXI.—Summary of Results Obtained During the Winter of 1895-96.

NAME.	No. Weeks	Total D. M.	Ave. Daily D. M.	D. M. per 1000 lbs. Live W'ght	Ave. Weekly Cost	Cost of Feed	Lbs. of Milk	Per cent. Fat	Lbs. of Fat	Lbs. of Butter	Cost of 100 lbs. Milk Cents	Cost of 1 lb. Butter Fat Cents	Cost of 1 lb. Butter Cents	D. M. for 1 lb. Butter Fat	D. M. for 1 lb. Butter
Belle.....	24	4154.01	24.72	25.08	57.46	\$13.79	4159.6	3.80	158.19	184.56	33.15	8.72	7.47	26.26	22.51
Berry.....	32	4507.42	20.12	21.34	45.72	14.63	3646.4	4.48	183.49	190.74	40.12	8.92	7.67	27.57	23.63
Counless.....	25	5506.43	31.47	26.33	72.92	18.23	8292.2	2.52	209.08	243.93	21.98	8.72	7.47	26.34	22.57
Duchess.....	28	4245.08	21.66	26.09	49.64	13.90	4092.9	4.87	194.87	227.35	34.72	7.13	6.11	21.78	18.67
Ethel.....	19	3951.51	22.94	19.95	53.32	10.13	2887.1	4.20	131.39	141.62	35.03	8.35	7.15	25.14	21.55
Fairy.....	32	4299.91	20.54	23.99	46.69	14.94	4536.5	3.92	177.62	207.22	32.93	8.41	7.21	25.90	22.20
Fortune.....	19	3406.69	25.61	26.82	59.74	11.35	4611.5	4.58	211.43	246.67	24.21	5.37	4.60	16.11	13.81
Houston.....	22	3513.15	22.81	24.85	52.92	11.65	4809.1	4.95	237.99	277.66	24.22	4.90	4.20	14.76	12.65
Ida.....	33	5135.34	22.23	19.64	50.82	16.77	4641.4	3.66	159.72	198.01	36.13	9.88	8.47	30.26	25.93
Low.....	27	4664.52	24.68	20.00	56.81	15.34	5292.0	3.60	190.70	222.48	28.99	8.04	6.90	24.46	20.97
Lydia.....	20	3675.81	23.72	22.46	61.15	12.23	4623.3	3.20	147.77	172.40	26.45	8.28	7.09	24.88	21.32
Maud.....	22	3652.81	23.72	21.54	54.64	12.02	4134.9	3.57	177.63	172.24	29.07	8.14	6.98	24.74	21.21
Nora.....	28	4469.08	22.80	23.46	52.14	14.60	3998.3	4.37	188.32	202.21	36.78	8.42	7.22	25.79	22.10
Pride 3.....	27	3755.50	19.87	24.14	45.52	12.29	4808.3	3.92	156.97	194.80	34.95	6.51	5.58	19.90	17.06
Quide.....	34	4632.60	15.78	22.87	36.03	12.25	4894.6	4.76	166.74	201.53	31.24	7.34	6.29	22.49	19.29
Riddle 2.....	30	4312.00	22.00	22.28	50.96	15.29	4895.1	3.53	178.10	207.78	33.12	8.85	7.59	26.82	22.99
Reddy.....	28	3532.90	14.42	24.53	51.00	14.28	3378.8	5.27	137.21	148.41	40.21	9.06	6.87	24.21	20.75
Shorty.....	35	5292.00	21.60	22.64	32.91	11.52	4525.5	4.44	197.96	230.95	41.52	8.71	7.46	26.73	23.81
Sophie.....	35	5292.00	21.60	23.15	49.26	17.22	4525.8	4.77	253.86	296.17	32.75	6.78	5.81	20.56	17.62
Sweet Briar.....	30	5218.50	24.85	23.09	57.41	17.22	4525.8	4.83	332.18	375.88	26.48	7.08	6.07	21.60	18.51
Topsy.....	30	6959.40	33.14	27.03	76.01	22.80	8611.7	3.74	204.22	238.26	35.15	6.84	5.86	20.74	17.78
Tricksey 2.....	28	4235.56	21.12	25.99	49.86	13.96	3971.6	5.14							

The foregoing table gives a general summary of the record of each cow from the time she came into milk until she was turned to pasture, the number of weeks she was in milk, the pounds of dry matter consumed, the dry matter consumed per day, the pounds of dry matter per thousand pounds live weight, the average cost for feed per week, the cost for feed from the time she came in until turned to pasture, the pounds of milk yielded, its average per cent. fat, the pounds of fat and butter equivalent, the cost of a pound of butter fat, the cost of a pound of butter and the dry matter consumed to a pound of butter fat and butter.

While the cows were under exactly the same conditions during the winter, so far as the care and feed were concerned, there was considerable difference as to the length of time they were in milk and their condition when they came in. Berry, Duchess, Ida, Shorty and Sophie came in in September, made a long journey by rail when fresh in milk, and were placed in a strange herd and in strange quarters. Fortune was under similar conditions though she did not come in until she became accustomed to the change. The same was the case with Countess and Quidee. Pride 3d and Reddie 2d were heifers. All the cows were in good working condition during the winter. All except Houston ate their full ration every day. During a few weeks in February her rations were reduced some on account of a tumor on her jaw. She was, however, watched so closely and handled so skillfully that no serious shrinkage occurred in her milk flow or butter fat. To show that there is a marked difference in cost of production and dry matter required to produce a pound of butter with cows that are in exactly similar condition in everything save type, the cases of Maud and Houston are cited. They calved at the same time and were under similar care. The same was the case with Ethel and Fortune. For the information of the average farmer who does not care to figure out results for himself it may be well to state that the herd gave

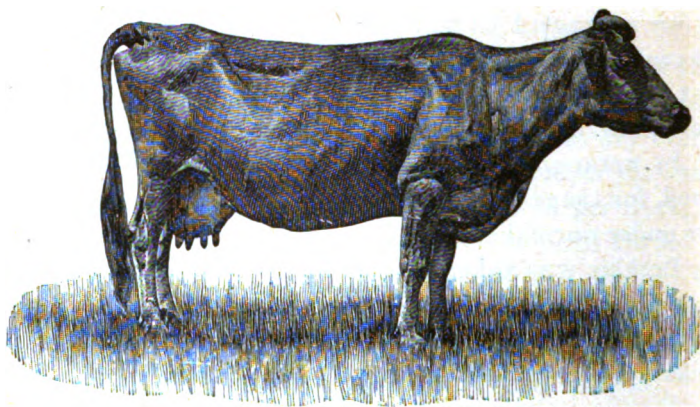
on an average 1.13 pounds of butter per day; that it cost 7.4 cents worth of feed to keep a cow a day; and that the cost of feed to produce a pound of butter was 6.59 cents for the winter, and 31.3 cents to produce 100 pounds of milk.

In arranging the cows into two groups not all are listed, for the reason that some were heifers and others were not under normal condition.

Beckley was taken out because she aborted during the summer of 1895; Countess, because of her age and impaired digestion; Nora, Pride and Reddie 2d, because they were heifers; Olive, because she belonged to neither class.

Dividing the remainder of the herd into two groups, placing in the first all the cows that have deep bodies through the middle and that have no marked tendency to gain or carry superfluous flesh, and in the second group all cows having a tendency to carry superfluous flesh, their comparative value for the dairy will be shown.

The following table gives the names of the cows in this group, the number of weeks they were in the trial counting from the time each came in until she went to pasture, their average weight, breeding, cost of feed, pounds of butter produced, pounds of dry matter required to produce a pound of butter, pounds of butter produced from a hundred pounds of dry matter and the cost of a pound of butter:



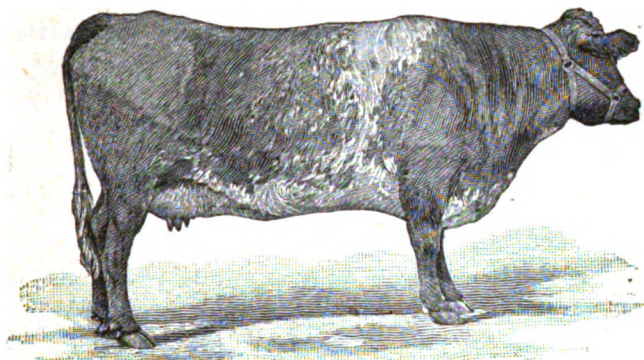
Houston.

TABLE LXXII.—Group I. Cows Spare and Angular with Deep Bodies.

NAME.	Weeks	Average Weight	Breed	Cost of Feed	Lbs. of Butter	Lbs. D.M. per 1 lb. Butter	Lbs. butter per 100 lbs D. M.	Cost of 1 lb. of Butter
Duchess.....	28	796	Jersey.....	\$13.90	227.35	18.67	5.35	Cts. 6.11
Fortune.....	19	941	Jersey.....	11.33	246.67	13.81	7.24	4.60
Houston.....	22	929	Jersey-Guer.....	11.65	277.66	12.65	7.90	4.20
Sweet B.....	30	1066	Guernsey.....	17.22	296.17	17.62	5.67	5.81
Topsy.....	30	1203	Gr. H. F.....	22.80	375.88	18.51	5.40	6.07
Tricksey 2.....	28	838	Guernsey.....	13.96	238.26	17.78	5.62	5.86
Average.....				\$15.14	277.00	16.59	6.03	5.47

The amount of dry matter required to produce a pound of butter ranged from 12.65 pounds with Houston to 18.67 with Duchess and averaged 16.59 for the group. There was a slight tendency to smoothness on the part of Duchess, Sweet Briar and Topsy. Fortune, Houston and Tricksey 2d were very spare, but the latter was still using some of her feed for growth. The productive capacity of each cow is clearly shown by the amount of butter produced from a hundred pounds of dry matter. Houston returned 7.9 pounds while Duchess returned 5.35 and the group averaged 6.03 pounds. The cost for feed to produce a pound o

butter ranged from 4.2 cents with Houston to 6.11 cents with Duchess while the average for the group is 5.47 cents. The table shows very clearly that the less flesh a cow carries, other things being equal, the less the cost of production. Of this group Houston carried the least flesh and Duchess the most.



ETHEL.

TABLE LXXIII.—Group II.—Cows Having a Tendency to Carry Superfluous Flesh.

NAME.	Average Weight	Breed	Cost of Feed	Lbs. of Butter	Lbs. D.M. per 1 lb. Butter	Lbs. butter per 100 lbs D. M.	Cost of 1 lb. of Butter
Belle.....	24 994	Gr. S. H.....	\$13.79	184.56	22.51	4.44	7.47
Berry.....	32 940	Gr. S. H.....	14.63	190.74	23.63	4.23	7.67
Ethel.....	19 1171	Gr. S. H.....	10.13	141.62	21.55	4.64	7.15
Fairy.....	32 860	Gr. S. H.....	14.94	207.22	22.20	4.50	7.21
Ida.....	33 1149	Gr. S. H.....	16.77	198.01	25.93	3.85	8.42
Lou.....	27 1236	Gr. H. F.....	15.34	222.48	20.97	4.77	6.90
Lydia.....	20 1179	Swiss.....	12.23	172.40	21.82	4.69	7.09
Shortie.....	35 641	Native.....	11.52	148.41	23.81	4.20	7.76
Maud.....	22 1100	Gr. S. H.....	12.02	172.24	21.21	4.72	6.98
Sophie.....	35 942	Gr. S. H.....	17.24	230.95	22.91	4.36	7.46
Average.....			\$13.86	186.86	22.61	4.42	7.42

With a single exception none of the cows in Group II. would be classed as having a strong tendency to convert feed into flesh and all were what would ordinarily be termed

good cows, with possibly the single exception of Ethel that in conformation showed strong leaning towards beef. Lou, Lydia and Maud were fair dairy cows, but their shoulders and thighs were rather heavy and they carried more flesh than any of the cows in Group I. The pounds of dry matter required to produce a pound of butter ranged from 20.97 to 25.93 and averaged 22.61. They returned on an average 4.42 pounds of butter for 100 pounds of dry matter consumed. The cost for feed to produce a pound of butter ranged from 6.9 cents with Lou to 8.42 cents with Ida and averaged 7.42 cents. It cost 35.64 per cent. more to produce a pound of butter from Group II. than it did from Group I.

Data covering only a few months during the first part of the period of lactation does not fully reveal the adaptability of a cow for the dairy, because most any kind of a cow will do fairly well for a few months after calving. The real test comes later, when the temporary stimulus of the lacteal functions produced by parturition loses its force and then the tendency to lay on flesh, by a certain style of cow, becomes more pronounced. The only one that fairly represents the average cow on our western farms is Ethel, though her yield of butter is much greater than statistics give as the average yield of the cows in the West. Ethel was of the blocky type; her hook points were well rounded; shoulders broad; cylindrical body; ribs, loin and back well padded with flesh; chest deep and flanks low, giving her a level top and bottom line; thighs full and when fresh she carried a fine udder and gave a good mess of milk. She was greatly admired by farmers visiting the Station and was frequently pointed out as the ideal farmer's cow. Houston, in Group I., was of the extreme angular type; her hook points were sharp; shoulders narrow; body flat or what is often termed "slabsided;" her ribs, loin and back were free from flesh; chest narrow and lacking in depth; flanks cut up; body long; bottom line concave giving her a "pot bellied"

appearance; thighs spare and rear line incurving; very short from hook points to pin bones; prominent rump and spinal column; light neck; top line dropping down from the withers; and head rather heavy. The chart shows the amount that each cow charged during each week to produce a pound of butter from the time she came in until turned to pasture.

The squares running vertically represent cost in cents to produce a pound of butter, and the squares running horizontally represent weeks.

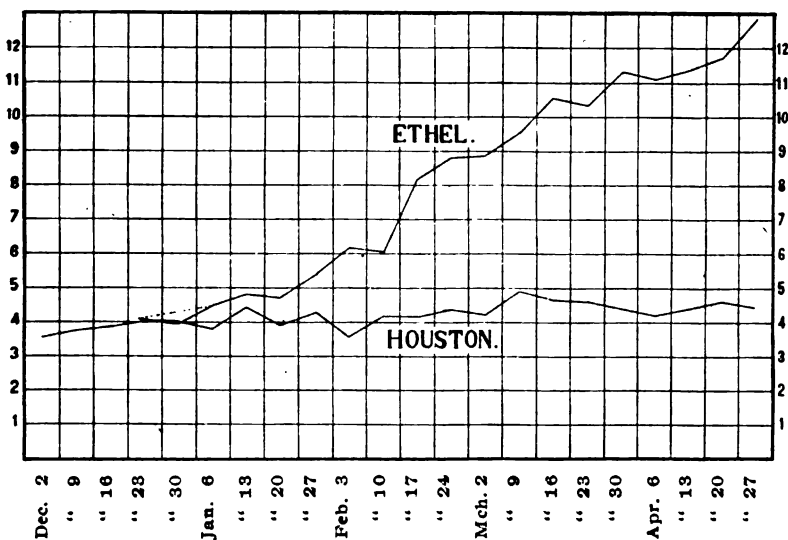


Chart showing weekly cost of butter by each cow.

Houston came in on the 30th of November, and her record begins with Monday, December 2d. Ethel dropped her calf the 20th of December, and her record began Monday, the 23d. On the morning of the 4th of May they were turned out to pasture.

During the first week Houston produced butter at a cost of 3.5 cents per pound. The cost gradually increased up to the fourth week when she charged 4 cents. The greatest cost during the winter was 4.9 cents for the week ending

March 15th. Ethel charged the first week 4.1 cents for a pound of butter. The second week she produced it for 4 cents, and then the cost rapidly increased until, for the week ending May 3d, it reached 12.8 cents per pound.

There was but little difference in the weekly butter yield between the two cows when they were fresh. The largest yield was by Houston during the first week, when she gave 13.65 pounds. Ethel's best yield was during the second

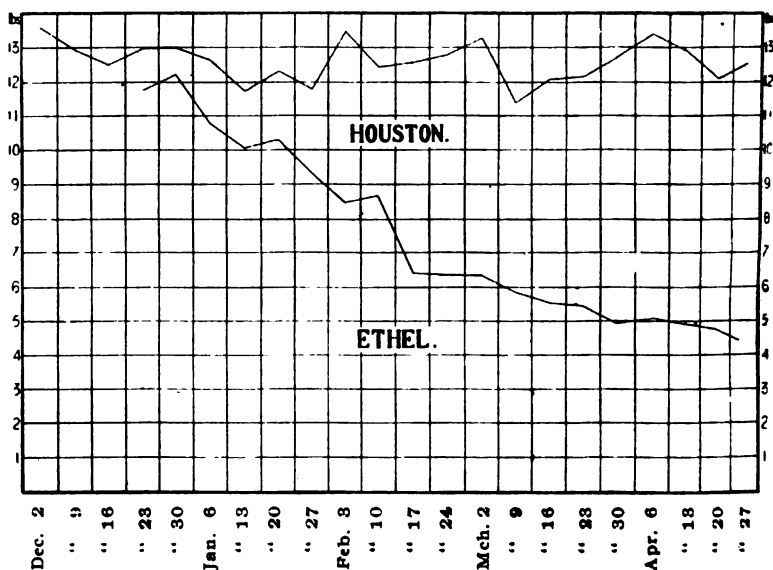


Chart showing the weekly yield of butter by each cow.

week, when she gave 12.2 pounds. The week before being turned out to pasture, Houston gave 12.62 pounds and Ethel 4.39 pounds. The cows had the same care and were in every way under similar conditions, except as to breeding and conformation. Houston's daily ration contained on an average 22.81 pounds of dry matter, while Ethel's contained 22.94 pounds. Houston, during her period of lactation, gave 512 pounds of butter, and Ethel gave nearly 19

pounds, which shows that a cow having the proper dairy form and heredity may be a superior cow for the dairy and yet not make a yield of 14 pounds a single week during her lifetime, while another cow, not having the dairy form and dairy heredity, may make over 12 pounds when fresh and still be a poor cow for the dairy. Houston was killed at the close of her lactation, having reached that point in life when most cows fail to breed. Ethel was killed for the same reason, though she had only passed her sixth year.

RECORD OF COWS DURING PERIOD OF LACTATION.

Thus far the published records have been compiled for the calendar year,—the year commencing with the Monday nearest the 1st day of January. While such a record is entirely satisfactory in making comparisons of the feed consumed and milk and butter produced and the cost of same, yet it does not show the yield of milk and per cent. fat content in the different milkings, nor the various changes that take place as the time of lactation advances. To publish in detail the record of every cow would occupy more space than can be given in a report of this character, and to publish a summary of each week's work, the changes that occur at different milkings and on different days would not be shown. After careful study it was decided that the most useful information would be given by publishing in detail the number of pounds of milk given at each milking the first week, the per cent. fat content, total fat yielded at each milking, the pounds of milk given each day during the first week, its daily average per cent. fat, daily yield of butter fat, and its butter equivalent, which is obtained by adding one-sixth to the butter fat. Also a summary of four weeks' record, about equally distributed through the period of lactation, giving the amount and kind of feed consumed during the week indicated by the dates in the first column, the cost of the feed, the pounds of milk, the average per cent. fat, total butter fat and butter equivalent, and cost of each. Next is given the record for the period of lactation, arranged in periods of four weeks each. In giving the cost of feed and the average cost to produce a pound of butter during the period of lactation it should be understood that it is not the total cost for the year, for the obvious reason that no account is taken in

these tables of cost of feed when the cow is not in milk. In the record of the herd for the year 1896, which will follow these tables, account is taken for cost of feed during the year and the actual average cost of a pound of butter. The charge for pasture was not the same for each cow, as all cows do not eat the same amount of grass; so each one is charged in proportion to the amount of feed she consumed during the winter months.

The hay was a sedge variety that grew on the Chippewa River bottom lands, in Swift county, that overflow in the spring and are wet much of the time during the growing season. The hay was very uniform, containing practically no mixtures of other varieties, rather coarse, two and a half to three feet in length, was apparently cut early and was greatly relished. Samples of the hay were analyzed, which showed a dry matter content of 82.94 per cent. It contained about 20 per cent. more protein than timothy hay.

The grain was a mixture of six parts bran, valued at \$6.50 per ton; four parts ground barley at 16 cents per bushel; three parts ground oats at 14 cents per bushel, and one part oil meal at \$14 per ton.

The ensilage was from dent corn planted in hills. That used from the fall until the 27th of January contained only 14.85 per cent. dry matter, and was priced at \$1.00 per ton. That fed during the week of January 27th-31st contained 19.06 per cent. dry matter, and was valued at \$1.25 per ton, and that fed the remainder of the season contained, on an average, 24.04 per cent. dry matter and was charged at the rate of \$1.60 per ton.

Records for only twelve cows are given, because in the spring the herd was divided, part being sent to the sub-station at Grand Rapids, part to the sub-station at Crookston, and part retained here. Three that were retained were not bred until some time in December, so they would come fresh in the fall of the next year, and on this account their

period of lactation was continued from 60 to 68 weeks, which is unusual and abnormal.

In studying the tables it should be borne in mind that all the scales used in the Dairy Division have beams that are divided into pounds and decimals of a pound; that there are ten spaces between the pound marks, each space registering one-tenth of a pound; and that there are no ounce marks. This greatly simplifies the work of making calculations. Taking, for example, the record of Belle's performance, the first week shows that Monday morning, November 18th, she gave 14.5 pounds of milk, which tested 3.6 per cent. fat and yielded .52 of a pound of butter fat. In the evening she gave 10.4 pounds of milk, testing 3.2 per cent. fat, which yielded .33 of a pound of butter fat. Following along the line we find that she gave that day 24.9 pounds of milk, testing on an average 3.41 per cent. fat, which amounts to .85 of a pound of butter fat, and is equivalent to .99 of a pound of butter. The morning of the 19th of November she gave 14.1 pounds, testing 3.5. In the evening she gave 11.2 pounds, testing 3.1. On the morning of the 23d she gave 14 pounds of milk, testing 3.5, while in the evening she gave only 12.3 pounds, testing only 3 per cent. Sunday morning, the 24th, she gave 13.7 pounds, testing 3.9 per cent., while in the evening she gave 11.1 pounds, testing 4.4 per cent. Examining the column under the heading of "total," we find that her daily yield of milk ranges from 23.6, on the 21st, to 26.3, on the 23d; that the per cent. fat of her milk was on Saturday, the 23d, 3.27, while on Sunday, the 24th, it tested 4.11; that she gave in the week 174.7 pounds of milk, testing 3.46 per cent. fat, yielding 6.04 pounds of butter fat and 7.05 of butter.

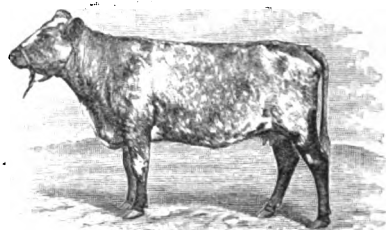
Taking the second table in Belle's record, where a summary of four weeks' work is given separately,—the first week being the one just examined in detail, the second being the record for the week ending January 26th, the third the week ending April 12th and the fourth the week ending June 28th,—

we can see the amount of hay, grain and ensilage she consumed each week, what it cost to feed her, how much milk she gave each week, its fat content, the pounds of fat and butter yielded and the cost of same. The table also reveals the changes that take place in the different stages of her lactation in the flow of milk, per cent. fat, yield of butter and the cost.

The third table is divided into periods of four weeks each; that is, what she did the first four weeks, the second four weeks, the third four weeks, and so on until she went dry. It shows the difference in cost of food between summer and winter, the difference in the flow of milk and per cent. fat between stall feeding and grazing in pasture, the difference in yield of butter and cost of production.

A careful examination of the tables shows that cows differ as to the variation in the flow of milk at different milkings, some varying little, while others vary comparatively much. The same is true in regard to the per cent. of fat. The milk of some cows seems to be influenced more by the feed than is the case with others. Countess' milk remained constant in per cent. fat during her lactation, it being no richer in butter fat the last eight weeks than it was the first eight. Duchess during the first 20 weeks never averaged as high as 5 per cent., while she never dropped below 5.2 while on pasture. Ethel's milk never dropped below 4 per cent. during the 20 weeks she was on dry feed, while the first 12 weeks on pasture her milk was always below 4 per cent.

The most radical change that a cow can be subjected to, so far as feed is concerned, is from a generous dry feed to a luxuriant pasture. What influence such a change had on these cows a careful examination of the tables will show. With some there was a noticeable increase in per cent. fat on pasture; with others it remained practically stationary; while with some others there was a marked decrease. Surely the ways of the cow are very strange. She does and she doesn't, and then again she does neither.



BELLE.

Daily Record for Week—Nov. 18-24, 1895.

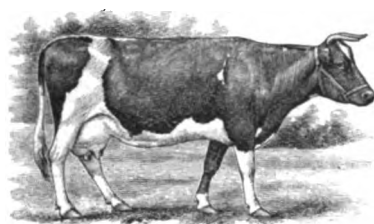
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Nov. 18.....	14.5	3.6	.52	10.4	3.2	.33	24.9	3.41	.85	.99
Nov. 19.....	14.1	3.5	.49	11.2	3.1	.35	25.3	3.32	.84	.98
Nov. 20.....	14.1	3.4	.48	11.6	3.3	.38	25.7	3.35	.86	1.00
Nov. 21.....	12.8	3.4	.43	10.8	3.4	.37	23.6	3.40	.80	.93
Nov. 22.....	13.7	3.3	.45	10.4	3.5	.36	24.1	3.36	.81	.95
Nov. 23.....	14.	3.5	.49	12.3	3.	.37	26.3	3.27	.86	1.00
Nov. 24.....	13.7	3.9	.53	11.1	4.4	.49	24.8	4.11	1.02	1.19
							174.7	3.46	6.04	7.05

Record for the Four Weeks—Nov. 18-24, 1895; Jan. 20-26, April 6-12, June 22-28, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Nov. 18-24....	49.	91	98.	Cents 45.6	174.7	3.46	6.04	7.05	Cents 7.55	Cents 6.47
Jan. 20-26....	63.	112	161.	59.5	194.1	3.66	7.11	8.30	8.36	7.16
April 6-12....	59.5	105	150.5	60.3	147.	4.29	6.31	7.36	9.55	8.19
June 22-28....		14	Pasture	33.7	128.9	4.06	5.23	6.10	6.45	5.53

Record of Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter
	Hay	Grain	Ensilage						
1.....	210.	371	462.	\$1.92	680.4	3.75	25.51	29.76	Cents 6.45
2.....	224.	392	560.	2.08	813.2	3.66	29.75	34.71	5.99
3.....	248.5	441	633.5	2.37	778.9	3.55	27.63	32.24	7.35
4.....	241.5	427	612.5	2.45	692.4	3.72	25.79	30.09	8.14
5.....	238.	420	602.	2.41	593.5	3.89	23.11	26.96	8.94
6.....	238.	420	602.	2.41	581.5	4.22	24.54	28.63	8.42
7.....	80.	191	170.	1.65	649.6	4.10	26.61	31.05	5.31
8.....		70	Pasture	1.35	589.9	3.99	23.51	27.43	4.92
9.....		56	Pasture	1.35	428.7	4.44	19.03	22.20	6.08
10.....		49	Pasture	1.04	196.5	4.81	9.45	11.03	9.43
				19.03	6004.8	3.91	234.93	274.09	6.94



COUNTESS.

Daily Record for Week—Nov. 11-17, 1895.

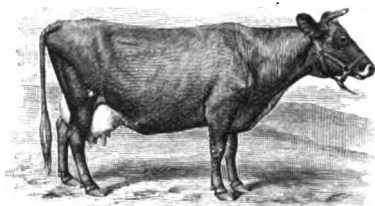
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Nov. 11.....	28.1	2.3	.64	24.2	2.2	.53	52.3	2.26	1.17	1.36
Nov. 12.....	30.2	3.4	1.02	24.5	2.5	.61	54.7	2.98	1.63	1.90
Nov. 13.....	26.	2.7	.70	23.	2.9	.67	49.	2.81	1.37	1.60
Nov. 14.....	25.3	2.6	.68	23.2	3.	.70	49.5	2.79	1.38	1.61
Nov. 15.....	25.6	3.	.77	23.2	2.6	.63	48.8	2.87	1.40	1.64
Nov. 16.....	24.	3.1	.74	22.5	2.4	.54	46.5	2.76	1.28	1.49
Nov. 17.....	25.3	3.	.76	21.	3.2	.67	46.3	3.09	1.43	1.67
							347.1	2.78	9.66	11.27

Record for the Four Weeks—Nov. 11-17, 1895; Jan. 6-12, March 16-22, May 25-31, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Nov. 11-17....	84.	91	70	Cents 49.5	347.1	2.78	9.66	11.27	Cents 5.12	4.39
Jan. 6-12....	84.	147	210	78.2	377.7	2.29	8.64	10.08	9.05	7.76
Mch. 16-22....	73.5	133	189	76.	297.5	2.48	7.38	8.61	10.29	8.82
May 25-31....	.....	28	Pasture	40.	163.3	2.58	4.22	4.92	9.46	8.12

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Butter Fat	Butter	Cost 1 lb. of Butter
	Hay	Grain	Ensilage	Roots						
1.....	287.	357.	294.	.....	\$1.93	1327.9	2.56	33.96	39.62	Cents 4.9
2.....	320.6	560.	801.5	.....	2.98	1502.4	2.47	37.15	43.34	6.9
3.....	336.	588.	840.	.....	3.13	1493.5	2.32	34.63	40.40	7.7
4.....	302.4	532.	680.7	42.	2.99	1309.7	2.57	33.69	39.31	7.6
5.....	294.	532.	756.	.....	3.04	1228.8	2.52	30.96	36.12	8.4
6.....	294.	532.	756.	.....	3.04	1157.3	2.67	30.89	36.04	8.4
7.....	178.	348.	414.	Pasture	2.49	1064.0	2.77	29.50	34.42	7.2
8.....	.....	98.	.....	Pasture	1.68	539.5	2.56	13.80	16.10	10.4
9.....	.....	14.	.....	Pasture	.77	40.9	2.42	.99	1.15	67.
					22.05	9664.0	2.54	245.57	286.50	7.7



DUCHESS.

Daily Record for Week—Oct. 28-Nov. 3, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 28.....	13.7	3.8	.51	13.3	4.1	.55	27.0	3.93	1.06	1.23
Oct. 29.....	15.2	4.4	.67	12.4	4.4	.54	27.6	4.40	1.21	1.41
Oct. 30.....	14.	3.9	.55	11.6	4.5	.52	25.6	4.18	1.07	1.25
Oct. 31.....	12.7	4.4	.55	10.3	4.5	.46	23.0	4.43	1.01	1.18
Nov. 1.....	13.1	4.2	.54	11.	4.2	.46	24.1	4.20	1.00	1.17
Nov. 2.....	18.3	4.3	.58	11.8	4.2	.49	25.1	4.26	1.07	1.25
Nov. 3.....	12.5	4.6	.57	10.5	4.8	.51	23.0	4.70	1.08	1.26
							175.4	4.28	7.50	8.75

Record for the Four Weeks—Oct. 28-Nov. 3, 1895; Jan. 6-12, March 30-April 5, June 22-28, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 28-Nov. 3	70.	84.	56.	Cents 44.1	175.4	4.28	7.50	8.75	Cents 5.88	Cents 5.04
Jan. 6-12.....	52.5	91.	129.5	48.4	154.3	4.66	7.19	8.39	6.74	5.77
Mch. 30-Apr. 5	52.5	91.	126.	52.	120.6	5.70	6.88	8.03	7.56	6.48
June 22-28....	.....	14.	Pasture	29.9	104.4	5.51	5.78	6.74	5.18	4.44

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Butter Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Ensilage	Roots						
1.....	294.	336.	70.	168.	\$1.79	673.5	4.34	29.22	34.09	Cents 5.25
2.....	213.5	364.	479.5	.....	1.92	649.1	4.70	30.52	35.61	5.39
3.....	210.	364.	518.	.....	1.94	625.9	4.83	30.23	35.27	5.50
4.....	210.	364.	518.	.....	2.00	588.3	4.55	26.78	31.24	6.39
5.....	210.	364.	518.	.....	2.09	508.0	4.90	24.91	29.06	7.18
6.....	210.	364.	511.	.....	2.09	480.6	5.43	26.12	30.47	6.53
7.....	210.	364.	504.	.....	2.08	477.5	5.67	27.09	31.61	6.58
8.....	20.5	79.	24.	Pasture	1.15	518.1	5.36	27.75	32.88	3.55
9.....	.....	56.	.....	Pasture	1.20	439.4	5.24	23.04	26.88	4.46
10.....	.....	42.	.....	Pasture	1.14	364.4	5.60	20.42	23.82	4.59
11.....	.....	.....	.....	Pasture	.49	39.9	5.54	2.21	2.58	18.99
					17.89	5364.7	5.00	268.29	313.01	5.70

RECORD OF COWS DURING PERIOD OF LACTATION. 423

DUCHESS.

Daily Record for Week—Oct. 5-11, 1896.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 5.....	20.	4.8	.96	17.	4.2	.71	37.0	4.51	1.67	1.95
Oct. 6.....	20.2	4.1	.83	18.	5.2	.94	38.2	4.63	1.77	2.07
Oct. 7.....	20.	4.6	.92	17.5	5.	.88	37.5	4.80	1.80	2.10
Oct. 8.....	19.1	4.8	.92	17.3	4.5	.78	36.4	4.67	1.70	1.98
Oct. 9.....	20.5	4.8	.88	18.5	4.5	.83	39.0	4.88	1.71	2.00
Oct. 10.....	20.	4.8	.96	18.4	4.9	.90	38.4	4.84	1.86	2.17
Oct. 11.....	19.7	5.2	1.02	19.1	4.8	.92	38.8	5.00	1.94	2.26
							265.3	4.69	12.45	14.53

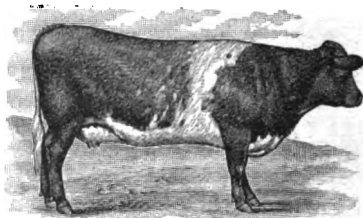
Record of Four Weeks—Oct. 5-11, 1896; Jan. 4-10, April 5-11, July 5-11, 1897.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	C. F.*	Grain	Roots							
Oct. 5-11.....	42.	56.	56.	Cents 34.4	265.3	4.69	12.45	14.53	2.76	2.37
Jan. 4-10.....	133.	91.	66.5	35.8	159.9	5.47	8.75	10.21	4.09	3.51
Ap'l 5-11.....		77.	231.	41.7	120.4	6.26	7.54	8.80	5.53	4.74
July 5-11.....			Pasture	27.5	144.9	5.28	7.65	8.93	3.59	3.08

Record for the Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Butter Fat	Butter	Cost 1 lb. of Butter
	C. F.*	Grain	Hay	Roots						
1.....	175.	238.		203.	\$1.39	943.	4.71	44.37	51.76	Cents 2.69
2.....		385.	385.		1.94	1064.8	4.75	50.56	58.99	3.29
3.....		364.	364.		1.63	962.	4.84	46.58	54.34	3.00
4.....	465.5	364.	41.5	364.	1.46	694.1	5.11	36.48	42.56	3.43
5.....	588.	350.		164.5	1.50	544.3	5.77	31.38	36.61	4.10
				Ensilage						
6.....	476.	336.		336.	1.67	495.5	5.91	29.27	34.15	4.89
7.....	238.	322.		630.	1.67	490.9	6.30	30.94	36.10	4.63
8.....		189.	28.	483.	1.43	479.6	6.56	31.48	36.73	3.95
9.....		49.			1.14	560.9	5.62	31.52	36.77	3.10
10.....					1.10	554.1	5.28	29.27	34.15	3.22
11.....					1.10	573.6	5.46	31.29	36.51	3.01
12.....					1.10	551.7	5.46	30.12	35.14	3.13
					17.15	7914.5	5.35	423.26	493.80	3.47

*Corn Fodder.



ETHEL.

Daily Record for Week—Dec. 23-29, 1895.

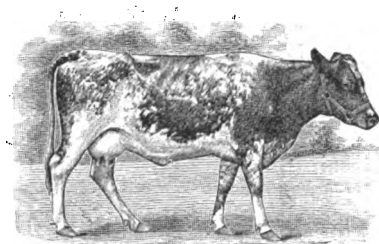
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Dec. 23.....	15.7	3.4	.53	13.9	3.5	.48	29.6	3.44	1.01	1.18
Dec. 24.....	17.2	4.8	.83	14.2	4.	.57	31.4	4.46	1.40	1.63
Dec. 25.....	16.7	4.8	.80	14.6	4.2	.61	31.3	4.53	1.41	1.64
Dec. 26.....	18.4	4.5	.83	15.9	4.6	.73	34.3	4.55	1.56	1.82
Dec. 27.....	17.4	4.5	.78	16.6	4.7	.78	34.0	4.59	1.56	1.82
Dec. 28.....	18.8	4.7	.88	16.4	4.9	.80	35.2	4.77	1.68	1.96
Dec. 29.....	17.6	4.7	.83	15.3	4.2	.64	32.9	4.47	1.47	1.72
							228.7	4.41	10.09	11.77

Record for the Four Weeks—Dec. 23-29, 1895; Feb. 3-9, April 20-26, June 20-26, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Dec. 23-29.....	52.5	91.	129.5	Cents 48.4	228.7	4.41	10.09	11.77	4.8	4.1
Feb. 3-9.....	52.5	91.	129.5	52.3	186.7	3.90	7.28	8.49	7.2	6.2
Ap'l 20-26.....	56.	98.	140.	56.3	96.7	4.26	4.12	4.81	13.7	11.7
June 20-26.....	14.	Pasture		31.8	56.9	3.93	2.24	2.61	14.2	12.2

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Butter Fat	Butter	Cost 1 lb. of Butter
	Hay	Grain	Ensilage						
1.....	210.	364.	518.	\$1.94	746.	4.23	31.57	36.83	5.26
2.....	210.	364.	518.	2.00	778.	4.20	32.71	38.16	5.24
3.....	217.	378.	539.	2.17	573.3	4.15	23.80	27.87	7.78
4.....	224.	392.	560.	2.25	460.1	4.03	18.58	21.68	10.37
5.....	224.	392.	560.	2.25	379.9	4.33	16.48	19.24	11.68
6.....	27.5	117.	33.	Pasture 1.37	354.5	3.93	13.94	16.25	8.43
7.....		63.		Pasture 1.30	308.3	3.77	11.61	13.54	9.60
8.....		56.		Pasture 1.27	263.6	3.97	10.48	12.23	10.38
9.....		77.		Pasture 1.35	160.6	4.08	6.56	7.65	17.64
10.....		56.	Corn Fod. 126.	Pasture .64	54.1	3.83	2.07	2.41	26.55
				16.54	4078.4	4.11	167.80	195.87	8.44



FAIRY.

Daily Record for Week—Sept. 23-29, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Sept. 23.....	19.9	3.57		13.7	3.24		32.7	3.09	1.01	1.18
Sept. 24.....	18.9	4.17		14.3	4.36		33.2	4.19	1.39	1.62
Sept. 25.....	19.5	3.16		14.6	5.27		34.1	3.99	1.36	1.59
Sept. 26.....	17.5	3.56		14.5	3.45		32.0	3.47	1.11	1.29
Sept. 27.....	17.3	3.45		15.3	3.35		32.3	3.37	1.09	1.27
Sept. 28.....	18.4	4.37		14.4	4.66		32.8	4.42	1.45	1.69
Sept. 29.....	17.8	4.71		14.8	3.87		32.6	4.36	1.42	1.66
							229.7	3.84	8.83	10.30

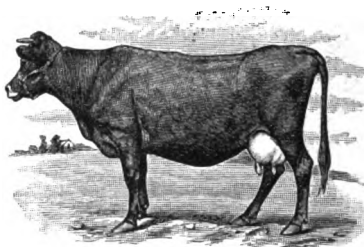
Record for the Four Weeks—Sept. 23-29, 1895; Jan. 27-Feb. 2, June 15-21, Nov. 2-8, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Sept. 23-29....	35	70	49 Ensilage	30.4	229.7	3.84	8.83	10.30	3.5	3.0
Jan. 27-Feb. 2	49	84	119 Pasture	46.5	135.8	3.89	5.28	6.16	8.8	7.6
June 15-21....	.....	14	77 Roots	29.9	109.4	4.20	4.60	5.37	6.5	5.6
Nov. 2-8.....	77	77	77	38.8	135.5	3.73	5.06	5.90	7.7	6.6

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter
	Hay	Grain	Roots	Sorghum						
1.....	145.	234.	147.	45.	\$1.10	737.5	3.62	26.71	31.16	3.53
2.....	259.	280.	168.		1.50	717.1	3.54	25.36	29.59	5.07
3.....	241.5	336.		Ensilage	1.80	631.1	3.63	22.89	26.71	6.74
4.....	227.5	399.			2.12	688.2	3.78	26.00	30.33	6.99
5.....	227.5	399.			2.14	608.1	3.88	23.58	27.51	7.78
6.....	185.5	315.			1.81	472.8	4.43	20.95	24.44	7.41
7.....	199.5	343.			1.97	353.4	4.43	15.65	18.26	10.79
8.....	210.	364.			2.09	307.2	4.72	14.50	16.93	12.34
9.....	175.	315.	Pasture		1.85	345.7	4.64	16.05	18.73	9.88
10.....		70.	Pasture		1.20	376.7	4.42	16.66	19.44	6.17
11-17.....	602.	1149.	791.	Corn Fod.	8.57	3210.3	3.71	119.07	138.93	6.17
					26.15	8448.1	3.88	327.42	381.99	6.85

During the eleventh, twelfth and thirteenth periods Fairy was on pasture.



FORTUNE.

Daily Record for Week—Dec. 23-29, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Dec. 23.....	18.2	4.5	.82	15.8	4.6	.73	34.0	4.55	1.55	1.81
Dec. 24.....	18.5	4.9	.91	16.	5.	.80	34.5	4.95	1.71	2.00
Dec. 25.....	18.3	4.6	.84	17.8	4.2	.75	36.1	4.40	1.59	1.86
Dec. 26.....	21.3	5.5	1.17	17.1	5.	.86	38.4	5.29	2.03	2.37
Dec. 27.....	19.8	5.2	1.03	17.9	4.6	.82	37.7	4.91	1.85	2.16
Dec. 28.....	20.1	3.6	.72	18.1	5.2	.94	38.2	4.35	1.66	1.94
Dec. 29.....	20.1	5.5	1.10	16.5	5.3	.87	36.6	5.38	1.97	2.30
							255.5	4.84	12.36	14.42

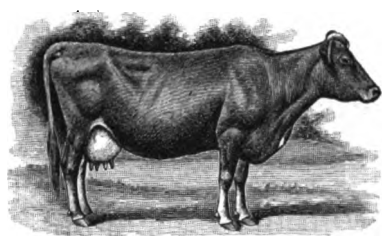
Record for the Four Weeks—Dec. 23-29, 1895; Jan. 20-26, April 6-12, Aug. 3-9, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Dec. 23-29.....	56.	98.	140.	52.1	255.5	4.84	12.36	14.42	4.2	3.6
Jan. 20-26.....	63.	112.	161.	59.5	265.3	4.67	12.38	14.44	4.8	4.1
April 6-12.....	59.5	112.	160.5	62.9	231.7	4.91	11.38	13.28	5.6	4.7
Aug. 3-9.....	28.		Pasture	40.9	169.2	4.85	8.20	9.57	5.0	4.3

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed			Cost	Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Ensilage						
1.....	224.	392.	560.	\$2.08	965.9	4.56	44.02	51.36	4.05
2.....	241.5	427.	612.5	2.33	1044.2	4.39	45.86	53.50	4.36
3.....	238.	420.	602.	2.41	937.5	4.61	43.18	50.38	4.78
4.....	238.	448.	602.	2.52	943.5	4.42	41.72	48.68	5.18
5.....	238.	441.	602.	2.49	895.6	4.96	44.43	51.84	4.80
6.....	24.	139.	30.	1.57	820.3	4.81	39.45	46.03	3.41
7.....		91.		1.56	788.4	4.43	34.90	40.72	3.83
8.....		63.		1.45	750.6	4.53	34.03	39.70	3.65
9.....		105.		1.61	643.1	4.79	30.81	35.95	4.48
10.....	Corn Fod								
11.....	322.	154.		1.46	486.4	4.93	23.98	27.98	5.22
				.25	70.9	5.49	3.89	4.54	5.51
				19.73	8346.4	4.63	386.27	450.65	4.38

RECORD OF COWS DURING PERIOD OF LACTATION. 427



HOUSTON.

Daily Record for Week—Dec. 2-8, 1895.

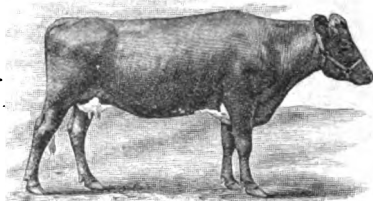
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Dec. 2.....	16.	5.2	.83	15.9	4.6	.73	31.9	4.89	1.56	1.82
Dec. 3.....	17.	5.4	.92	16.	4.2	.67	33.	4.82	1.59	1.86
Dec. 4.....	19.	4.6	.87	17.2	4.9	.84	36.2	4.72	1.71	2.00
Dec. 5.....	18.5	5.2	.96	16.8	4.6	.77	35.3	4.90	1.73	2.02
Dec. 6.....	19.	4.9	.93	16.9	4.9	.83	35.9	4.90	1.76	2.05
Dec. 7.....	19.5	4.7	.92	17.	4.7	.80	36.5	4.71	1.72	2.01
Dec. 8.....	19.	4.8	.91	16.6	4.8	.79	35.6	4.78	1.70	1.98
							244.4	4.82	11.77	13.73

Record for the Four Weeks—Dec. 2-8, 1895; Feb. 3-9, April 6-12, Aug. 3-9, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Dec. 2-8.....	52.5	91.	129.5	Cents 48.4	244.4	4.82	11.77	13.73	4.14	3.55
Feb. 3-9.....	49.	84.	119.	48.3	220.9	5.24	11.58	13.51	4.17	3.58
Apr. 6-12.....	56.	98.	140.	56.3	208.2	5.51	11.48	13.39	4.91	4.21
Aug. 3-9.....	28.		Pasture	37.1	170.5	4.79	8.16	9.52	4.55	3.90

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed			Cost	Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter
	Hay	Grain	Ensilage						
1.....	206.5	357.	507.5	\$1.90	794.1	4.46	35.43	41.34	Cents 4.60
2.....	220.	385.	550.	2.05	925.1	4.67	43.24	50.45	4.06
3.....	206.5	357.	507.5	1.99	859.4	5.00	42.96	50.12	3.97
4.....	220.5	385.	549.5	2.21	845.5	5.08	42.94	50.10	4.41
5.....	224.	392.	560.	2.25	837.1	5.16	43.17	50.37	4.47
6.....	192.	335.	450.	2.12	782.5	5.41	42.37	48.43	4.29
7.....		105.	Pasture	1.31	743.9	4.95	36.80	42.93	3.05
8.....		56.	Pasture	1.27	753.4	4.62	34.77	40.57	3.13
9.....		63.	Pasture	1.30	717.3	4.82	34.69	40.36	3.22
10.....		112.	Pasture	1.48	673.5	5.07	34.18	39.88	3.71
11.....	Corn Fod 441.	161.	Pasture	1.34	594.9	5.47	32.55	37.98	3.53
12.....	1.75	126.	Roots 126.	.87	270.6	6.13	16.58	19.34	4.50
				20.09	8797.3	5.00	439.58	512.84	3.92



IDA.

Daily Record for Week—Sept. 23-29, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Sept. 23.....	15.	3.2	.48	12.	4.	.48	27.	3.56	.96	1.12
Sept. 24.....	12.	3.9	.47	12.	3.7	.44	24.	3.80	.91	1.06
Sept. 25.....	13.4	3.6	.35	12.2	3.4	.41	25.6	2.97	.76	.89
Sept. 26.....	12.3	3.2	.39	10.7	2.8	.30	23.	3.00	.69	.81
Sept. 27.....	12.	3.3	.40	10.5	4.8	.50	22.5	4.00	.90	1.05
Sept. 28.....	11.1	3.5	.39	10.	3.8	.38	21.1	3.65	.77	.90
Sept. 29.....	12.	3.3	.40	10.	4.	.40	22.	3.64	.80	.93
							165.2	3.50	5.79	6.76

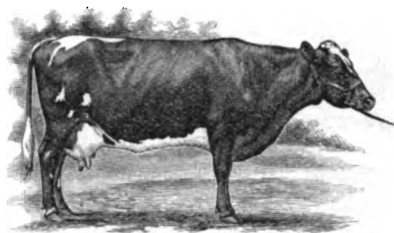
Record for the Four Weeks—Sept. 23-29, Dec. 16-22, 1895; April 6-12, Aug. 24-30, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Sept. 23-29....	42.	84.	56. Ensilage	36.4	165.2	3.50	5.79	6.76	6.29	5.38
Dec. 16-22....	56.	98.	140.	52.1	145.7	3.60	5.25	6.13	9.93	8.50
April 6-12....	56.	98.	140.	56.3	135.4	4.16	5.63	6.57	10.00	8.57
Aug. 24-30....	21.		Pasture	34.5	120.1	4.10	4.92	5.74	7.01	6.01

Record for Period of Lactation Arranged in Periods of Four Weeks Duration.

Period	Feed				Cost	Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter
	Hay	Grain	Corn	Fod. Roots						
1.....	168.	231.	350.	112.	\$1.23	650.6	3.27	21.28	24.83	4.95
2.....	238.	336.		224.	1.70	523.9	3.58	18.75	21.88	7.77
3.....	276.5	343.		Ensilage	1.86	534.4	3.53	18.86	22.00	8.45
4.....	220.5	385.		304.5	2.05	570.	3.63	20.71	24.16	8.49
5.....	238.	420.		549.5	2.23	599.8	3.62	21.71	25.33	8.80
6.....	224.	392.		602.	2.23	541.4	3.53	19.13	22.32	9.99
7.....	224.	392.		560.	2.25	542.8	3.89	21.09	24.61	9.14
8.....	224.	392.		560.	2.25	548.4	4.02	22.05	25.73	8.74
9.....	136.	242.	Pasture	310.	1.79	573.5	3.93	22.56	26.32	6.80
10.....		56.	Pasture		1.18	581.7	3.63	21.12	24.64	4.79
11-15..	434.		Corn Fod.	Roots	5.65	1983.2	4.13	81.83	95.47	5.92
			112.	406.	24.42	7649.7	3.78	289.09	337.27	7.24

During the eleventh, twelfth and thirteenth periods Ida was on pasture.



LIGGETTA.

Daily Record for Week—Oct. 14-20, 1895.

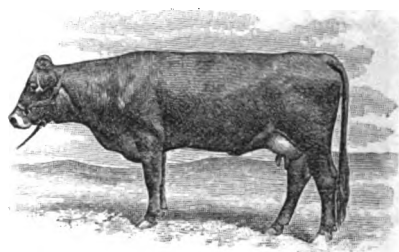
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Pat	Milk	Per Cent. Fat	Pat	Milk	Per Cent. Fat	Fat	Butter
Oct. 14.....	16.3	3.2	.52	14.5	2.8	.41	30.8	3.02	.93	1.09
Oct. 15.....	16.6	3.5	.58	16.3	3.	.49	32.9	3.25	1.07	1.25
Oct. 16.....	18.	3.2	.58	15.3	2.9	.44	33.3	3.06	1.02	1.19
Oct. 17.....	16.	2.8	.45	14.4	3.1	.45	30.4	2.96	.90	1.05
Oct. 18.....	15.2	3.	.46	15.1	3.6	.54	30.3	3.30	1.00	1.16
Oct. 19.....	17.7	3.6	.64	15.4	4.	.62	33.1	3.81	1.26	1.47
Oct. 20.....	17.1	2.9	.50	14.	2.3	.32	31.1	2.64	.82	.96
							221.9	3.15	7.00	8.17

Record for the Four Weeks—Oct. 14-20, 1895; Jan. 6-12, April 6-12, June 1-7, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 14-20.....	56.	98.	105.	Cents 49.6	221.9	3.15	7.00	8.17	Cents 7.05	Cents .604
			Ensilage							
Jan. 6-12.....	63.	112.	161.	59.5	194.7	3.16	6.16	7.19	9.65	8.27
Ap'l 6-12.....	63.	112.	161.	64.3	126.4	4.10	5.18	6.04	12.41	10.64
June 1-7.....		21.	Pasture	38.3	111.4	3.67	4.09	4.77	9.36	8.02

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Roots	Ensilage						
1.....	266.	420.	378.		\$2.13	771.9	3.38	26.08	30.43	7.00
2.....	266.	378.	84.	350.	2.01	746.4	3.18	23.74	27.70	7.26
3.....	234.5	413.		591.5	2.19	746.4	3.31	24.70	28.82	7.60
4.....	248.5	441.		633.5	2.34	759.3	3.28	24.93	29.09	8.04
5.....	252.	448.		644.	2.55	742.5	3.23	24.01	28.01	9.10
6.....	252.	448.		644.	2.57	704.2	3.48	24.53	28.62	8.98
7.....	252.	448.		644.	2.57	548.0	3.76	20.59	24.02	10.70
8.....	150.	285.	Pasture	344.5	2.10	529.5	3.95	20.93	24.42	8.60
9.....		84.	Pasture		1.42	464.1	3.57	16.56	19.32	7.35
10.....		28.	Pasture		.71	95.1	3.23	3.07	3.58	19.83
					20.59	6107.4	3.42	209.14	244.00	8.44



LYDIA.

Daily Record for Week—Dec. 16-22, 1895.

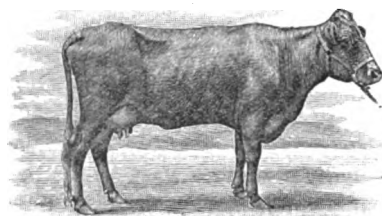
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Dec. 16.....	21.2	3.4	.72	18.3	3.5	.64	39.5	3.44	1.36	1.59
Dec. 17.....	19.	3.5	.67	17.4	3.4	.59	36.4	3.46	1.26	1.47
Dec. 18.....	18.9	3.2	.60	18.	3.3	.59	36.9	3.23	1.19	1.39
Dec. 19.....	19.4	3.4	.66	18.	3.5	.63	37.4	3.45	1.29	1.51
Dec. 20.....	20.4	3.	.61	19.2	3.4	.65	39.6	3.18	1.26	1.47
Dec. 21.....	20.2	3.	.61	18.5	3.3	.61	38.7	3.15	1.22	1.42
Dec. 22.....	19.1	3.3	.63	19.4	3.6	.70	38.5	3.45	1.33	1.55
							267.0	3.34	8.91	10.40

Record for the Four Weeks—Dec. 16-22, 1895; Feb. 10-16, April 20-26, Aug. 3-9, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Ensilage							
Dec. 16-22.....	56.	98.	140.	Cents 52.1	267.0	3.34	8.91	10.40	5.83	5.00
Feb. 10-16.....	63.	112.	161.	64.3	233.5	3.09	7.22	8.42	8.90	7.64
April 20-26.....	63.	112.	140.	62.6	199.1	3.43	6.82	7.96	9.18	7.86
Aug. 3-9.....	21.		Pasture	38.3	135.6	3.97	5.39	6.29	7.10	6.08

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost 1 lb. of Butter
	Hay	Grain	Ensilage						
1.....	227.5	399.	670.5	\$2.12	1017.8	3.27	33.26	38.80	5.46
2.....	252.	448.	644.	2.40	1064.0	2.99	31.82	37.12	6.47
3.....	252.	448.	644.	2.57	916.7	3.10	28.43	33.16	7.75
4.....	252.	448.	581.	2.52	831.0	3.28	27.28	31.83	7.92
5.....	252.	448.	560.	2.50	812.0	3.47	28.18	32.88	7.60
6.....	90.5	208.	173.	Pasture	1.80	852.2	3.49	29.70	34.65
7.....		77.		Pasture	1.45	825.3	3.45	29.16	34.02
8.....		56.		Pasture	1.43	690.2	3.77	26.03	30.37
9.....		77.		Pasture	1.50	570.9	3.96	22.60	26.37
10.....			Corn Pod.						
	112.	140.	Pasture	1.73	451.2	4.36	19.67	22.95	5.80
				19.62	8030.3	3.44	276.13	322.15	6.09



OLIVE.

Daily Record for Week—Oct 28-Nov. 3, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 28	13.6	3.6	.49	12.	4.1	.49	25.6	3.83	.98	1.14
Oct. 29	12.8	4.	.51	13.3	4.	.53	26.1	3.8	1.04	1.21
Oct. 30	15.8	3.8	.60	15.6	3.8	.59	31.4	3.80	1.19	1.39
Oct. 31	12.7	4.	.51	14.1	4.1	.58	26.8	4.07	1.09	1.27
Nov. 1	16.5	4.7	.78	14.	4.4	.62	30.5	4.59	1.40	1.63
Nov. 2	15.5	4.7	.73	13.8	5.	.69	29.3	4.85	1.42	1.66
Nov. 3	15.8	4.7	.74	14.1	3.8	.54	29.9	4.28	1.28	1.49
							199.6	4.21	8.40	9.80

Record for the Four Weeks—Oct. 28-Nov. 3, 1895; Jan. 20-26, April 20-26, July 20-26, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 28-Nov. 3	56.	56.	56. Ensilage	31.7	199.6	4.21	8.40	9.80	3.79	8.24
Jan. 20-26	49.	84.	119.	44.8	191.9	3.86	7.40	8.63	6.05	5.19
Apr. 20-26	52.5	84.	119.	48.9	147.2	4.27	6.28	7.33	7.80	6.67
July 20-26		14.	Pasture	30.7	118.6	4.53	5.37	6.27	5.71	4.89

Record for Period of Lactation Arranged in Periods of Four Weeks Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Ensilage	Roots						
1	288.	231.	77.	140.	\$1.30	647.1	4.16	26.95	31.44	Cents 4.13
2	196.	322.	427.		1.71	804.6	3.82	30.71	35.83	4.77
3	196.	336.	476.		1.79	810.9	3.66	29.67	34.62	5.17
4	196.	336.	476.		1.84	752.7	3.78	28.43	33.17	5.55
5	196.	336.	476.		1.93	652.2	3.93	25.62	29.89	6.46
6	210.	336.	476.		1.95	579.9	3.93	23.32	27.21	7.17
7	210.	336.	476.		1.95	579.8	4.27	24.78	28.91	6.76
8	20.5	86.	24.	Pasture	1.12	625.2	4.08	25.51	29.76	3.76
9		56.		Pasture	1.23	533.7	4.09	21.81	25.45	4.83
10		56.		Pasture	1.23	487.0	4.40	21.42	24.99	4.92
11		56.	Corn Fod.	Pasture	1.23	371.4	4.82	17.90	20.84	5.89
12		42.	105.	Pasture	.80	160.6	5.05	8.11	9.46	8.46
					18.08	7005.1	4.06	284.23	331.60	5.45

GUIDEE.

Daily Record for Week—Oct. 7-13, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 7.....	12.	4.3	.52	12.	4.1	.49	24.	4.21	1.01	1.18
Oct. 8.....	13.6	4.	.54	12.9	4.	.51	26.5	3.96	1.05	1.23
Oct. 9.....	13.5	4.	.54	11.	3.9	.43	24.5	3.96	.97	1.13
Oct. 10.....	12.4	4.1	.51	12.4	4.1	.51	24.8	4.10	1.02	1.19
Oct. 11.....	13.1	3.7	.48	12.4	5.9	.73	25.5	4.75	1.21	1.41
Oct. 12.....	14.4	3.9	.56	12.5	4.3	.54	26.9	4.09	1.10	1.28
Oct. 13.....	13.6	3.4	.46	12.5	3.9	.49	26.1	3.64	.95	1.11
							178.3	4.10	7.31	8.53

Record for the Four Weeks—Oct. 7-13, 1895; Jan. 13-19, April 13-19, July 13-19, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 7-13.....	42.	84.	49.	Cents 39.5	178.3	4.10	7.31	8.53	Cents 5.41	Cents 4.63
Jan. 13-19.....	56.	98.	Ensilage 140.	52.1	180.3	3.22	5.81	6.78	8.97	7.69
Apr. 13-19.....	56.	98.	140.	56.3	151.2	3.61	5.47	6.38	10.29	8.83
July 13-19.....	.....	14.	Pasture	31.8	88.8	4.66	4.14	4.83	7.69	6.59

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Roots	Ensilage						
1.....	196.	336.	203.	.....	\$1.59	616.5	4.00	24.63	28.74	5.53
2.....	196.	322.	112.	182.	1.61	602.9	3.50	21.09	24.61	6.54
3.....	213.5	371.	.....	528.5	1.97	647.8	3.60	23.30	27.18	7.22
4.....	224.	392.	.....	560.	2.08	704.7	3.39	23.92	27.91	7.45
5.....	224.	392.	.....	560.	2.20	680.9	3.34	22.74	26.53	8.29
6.....	224.	392.	.....	560.	2.25	645.6	3.46	22.35	26.08	8.63
7.....	224.	392.	.....	560.	2.25	635.0	3.39	21.52	25.11	8.96
8.....	192.	327.	Pasture	450.	2.09	608.8	3.73	22.71	26.50	7.89
9.....	.....	91.	Pasture	.....	1.26	587.4	3.32	19.49	22.74	5.54
10.....	.....	56.	Pasture	.....	1.27	506.0	3.66	18.53	21.62	5.87
11.....	.....	56.	Pasture	.....	1.27	349.6	4.55	15.92	18.57	6.84
12.....	.....	14.	Pasture	.....	.58	67.6	4.99	3.37	3.93	13.71
					20.42	6652.8	3.60	239.57	279.50	7.31

SHORTIE.

Daily Record for Week—Sept. 9-15, 1896.

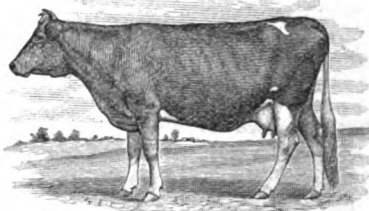
Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Sept. 9.....	8.2	4.	.88	5.5	4.4	.24	13.7	4.16	.57	.67
Sept. 10.....	6.5	3.2	.21	7.2	3.7	.27	13.7	3.50	.48	.56
Sept. 11.....	7.1	3.3	.23	6.9	4.	.28	14.0	3.64	.51	.60
Sept. 12.....	7.1	3.8	.27	5.8	3.5	.20	12.9	3.64	.47	.54
Sept. 13.....	6.5	4.	.26	6.	3.6	.22	12.5	3.44	.48	.56
Sept. 14.....	5.5	3.6	.20	5.2	3.9	.20	10.7	3.74	.40	.47
Sept. 15.....	7.5	3.4	.26	4.5	3.3	.15	12.0	3.42	.41	.48
	89.5	3.71	3.32							3.87

Record for the Four Weeks—Sept. 9-15, Dec. 9-15, 1896; March 9-15, June 8-14, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Corn Fodder							
Sept. 9-15.....	21.	35.	119. Ensilage	20.5	89.5	3.71	3.32	3.87	6.17	5.29
Dec. 9-15.....	42.	70.	98.	37.4	84.7	4.44	3.76	4.89	9.95	8.52
Mar. 9-15.....	35.	60.9	87.5	35.1	74.3	4.78	3.74	4.36	9.37	8.04
June 8-14.....	14.		Pasture	22.3	97.4	4.77	4.65	5.43	4.80	4.11

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Corn Fod.	Roots						
1.....	91.	161.	322.		\$.82	375.0	3.71	13.93	16.25	5.05
2.....	126.	196.		140.	.96	328.5	4.22	13.86	16.17	5.94
			Ensilage							
3.....	154.	217.	183.	70.	1.13	301.0	4.22	12.70	14.82	7.62
4.....	164.5	280.	399.		1.80	333.9	4.40	14.69	17.14	8.75
5.....	182.	308.	434.		1.64	349.4	4.46	15.59	18.19	9.02
6.....	167.3	287.	422.5		1.58	328.5	4.66	14.97	17.47	9.04
7.....	145.6	282.7	360.5		1.44	301.5	4.72	14.24	16.61	8.67
8.....	140.	243.6	360.0		1.40	298.0	5.11	15.23	17.77	7.88
9.....	122.	205.7	283.5	Pasture	1.32	339.3	4.98	16.89	19.71	6.70
10.....		56.		Pasture	.80	414.6	4.49	18.60	21.70	3.69
11-13.....		126.		Pasture	2.17	636.2	5.58	35.52	41.44	5.24
					14.76	4006.3	4.65	186.22	217.26	6.79



SWEET BRIAR.

Daily Record for Week—Oct. 7-13, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 7.....	12.4	3.1	.38	9.6	4.6	.44	22.0	3.73	.82	.96
Oct. 8.....	11.6	4.6	.53	10.	4.8	.48	21.5	4.70	1.01	1.18
Oct. 9.....	13.3	6.4	.85	11.	6.3	.69	24.3	6.34	1.54	1.80
Oct. 10.....	12.9	6.3	.81	11.5	4.8	.55	24.4	5.57	1.36	1.59
Oct. 11.....	14.6	6.8	.99	12.	4.3	.52	26.6	5.68	1.51	1.76
Oct. 12.....	14.5	4.5	.65	13.4	4.8	.64	27.9	4.62	1.29	1.51
Oct. 13.....	15.	4.6	.69	13.3	4.5	.60	28.3	4.56	1.29	1.51
							175.00	5.04	8.82	10.29

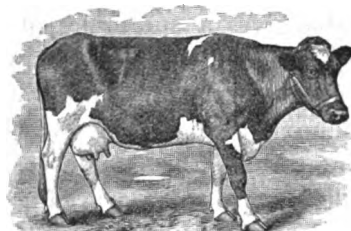
Record for the Four Weeks—Oct. 7-13, 1895; Jan. 6-12, April 6-12, July 6-12, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 7-13.....	42.	84.	70.	Cents 40.6	175.0	5.04	8.82	10.29	Cents 4.60	Cents 3.94
Jan. 6-12.....	63.	112.	Ensilage 161.	59.5	184.6	4.78	8.83	10.30	6.73	5.77
Apr. 6-12.....	63.	112.	161.	64.3	144.1	5.20	7.60	8.75	8.57	7.35
July 6-12.....			Pasture	30.4	83.4	5.17	4.31	5.03	7.05	6.04

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. of Butter
	Hay	Grain	Roots	Ensilage						
1.....	203.	308.	259.	.....	\$1.54	593.5	4.59	27.22	31.76	Cents 4.85
2.....	280.	357.	140.	189.	1.89	765.6	4.57	34.95	40.77	4.64
3.....	234.5	413.	.....	591.5	2.19	759.8	4.89	37.12	43.31	5.06
4.....	245.	434.	.....	623.	2.80	742.6	4.75	35.24	41.11	5.59
5.....	252.	448.	.....	644.	2.50	740.1	4.92	36.40	42.47	5.89
6.....	252.	448.	.....	644.	2.57	686.0	4.92	33.78	39.41	6.52
7.....	252.	448.	.....	644.	2.57	621.9	4.99	31.03	36.20	7.10
8.....	209.5	362.	Pasture	502.5	2.36	471.3	5.13	24.16	28.19	8.37
9.....	.....	63.	Pasture	.....	1.28	377.6	4.72	17.84	20.81	6.15
10.....	.....	28.	Pasture	.....	1.32	350.8	4.89	17.14	20.00	6.60
11.....	.....	.....	Pasture	.....	1.22	305.4	5.23	15.97	18.63	6.53
12.....	.....	.....	Pasture	.....	.61	120.1	5.45	6.54	7.63	7.99
					22.35	6534.7	4.86	317.39	370.29	6.04

RECORD OF COWS DURING PERIOD OF LACTATION. 435



TOPSY.

Daily Record for Week—Oct. 7-13, 1895.

Date	A. M.			P. M.			Total			
	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Milk	Per Cent. Fat	Fat	Butter
Oct. 7.....	21.	5.2	1.09	17.5	3.5	.61	38.5	4.42	1.70	1.98
Oct. 8.....	20.6	4.7	.97	17.	4.	.68	37.6	4.39	1.65	1.93
Oct. 9.....	20.7	4.2	.87	17.7	4.3	.76	38.4	4.24	1.63	1.90
Oct. 10.....	20.6	4.3	.89	17.9	4.4	.79	38.5	4.36	1.68	1.96
Oct. 11.....	20.	4.3	.86	17.6	3.7	.65	37.6	4.02	1.51	1.76
Oct. 12.....	22.2	4.	.89	18.2	4.3	.78	40.4	4.13	1.67	1.95
Oct. 13.....	20.3	4.2	.85	19.7	4.	.79	40.0	4.10	1.64	1.91
							271.0	4.24	11.48	13.39

Record for the Four Weeks—Oct. 7-13, 1895; Jan. 6-12, April 6-12, Aug. 3-9, 1896.

Date	Feed			Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost of 1 lb. Butter Fat	Cost of 1 lb. Butter
	Hay	Grain	Roots							
Oct. 7-13.....	56.	98.	84.	Cents 48.6	271.	4.24	11.48	13.39	Cents 4.23	Cents 3.63
Jan. 6-12.....	91.	161.	231.	85.5	324.3	3.69	11.98	13.98	7.14	6.12
Apr. 6-12.....	84.	140.	203.	81.3	284.9	3.90	11.12	12.97	7.31	6.27
Aug. 3-9.....		28.	Pasture	50.4	147.9	4.07	6.02	7.02	8.37	7.18

Record for Period of Lactation Arranged in Periods of Four Weeks' Duration.

Period	Feed				Cost	Lbs. of Milk	Per Cent. Fat	Fat	Butter	Cost 1 lb. of Butter
	Hay	Grain	Roots	Business						
1.....	259.	392.	364.		\$2.02	904.0	3.98	35.99	42.00	4.81
2.....	357.	420.	196.	224.	2.28	1088.7	3.89	42.35	49.41	4.61
3.....	339.5	595.		850.5	3.16	1219.3	3.72	45.41	52.98	5.96
4.....	364.	644.		924.	3.42	1223.3	3.67	44.90	52.38	6.53
5.....	343.	602.		861.	3.36	1155.0	3.80	42.85	49.99	6.72
6.....	336.	581.		833.	3.35	1154.4	3.65	42.16	49.19	6.80
7.....	336.	560.		812.	3.25	1153.0	3.54	40.79	47.59	6.83
8.....	290.	462.	Pasture	652.5	3.01	1040.7	3.91	40.70	47.4	6.34
9.....		133.	Pasture		1.87	917.6	3.79	34.79	40.59	4.61
10.....		84.	Pasture		1.91	833.6	3.83	31.94	37.26	5.13
11.....		91.	Pasture		1.94	722.3	4.33	31.29	36.51	5.31
12.....		105.	Pasture		1.99	314.3	4.14	13.02	15.19	13.10
					31.56	11726.2	3.81	446.19	520.56	6.06

The following table gives a summary of the record of the cows during the period of lactation. It will be noticed that the three grade shorthorn cows Fairy, Ida and Shortie were in milk more than a year, which was caused by a delay in breeding to have them come fresh later in the season and some difficulty was experienced in getting them in calf. Under normal conditions their lactation would not have run more than ten periods of four weeks each. Duchess' record does not give her yield for the full period of lactation, for the reason that she was not in the station herd when she came in, and making a long journey in a car without being milked caused her to shrink and make a poorer record than she would have done had she dropped her calf at the station.

TABLE LXXIV.—Giving Cost of Feed, Yield of Milk and Butter and Cost of a Pound of Butter During Period of Lactation.

NAME	Breed	In Milk Weeks	Cost of Feed	Milk Lbs.	Butter Lbs.	Cost of 1 Lb. Butter
Belle.....	Grade Shorthorn..	40	\$19.03	6004	274	Cents
Countess.....	Holstein.....	36	22.05	9684	286	6.94
Duchess.....	Jersey.....	44	17.89	5364	313	7.71
Ethel.....	Grade Shorthorn..	40	16.54	4078	196	5.70
Fairy.....	Grade Shorthorn..	68	26.15	8448	382	8.44
Fortune.....	Jersey.....	44	19.73	8346	450	6.85
Houston.....	Jersey-Guernsey..	48	20.09	8797	512	4.38
Ida.....	Grade Shorthorn..	60	24.42	7649	337	3.92
Liggetta.....	Grade Shorthorn..	40	20.59	6107	244	7.24
Lydia.....	Swiss.....	40	19.62	8080	322	8.44
Olive.....	Grade Guernsey....	48	18.08	7005	391	6.19
Quidee.....	Holstein.....	48	20.42	6652	279	6.45
Shortie.....	Native.....	52	14.76	4006	217	7.31
Sweet Briar.....	Guernsey.....	48	22.85	6534	370	6.79
Topsy.....	Grade Holstein.....	48	31.56	11726	520	6.04
Total.....			313.28	108410	5083	6.06
Average.....				7227	335	6.2

The table shows a fairly satisfactory yield for the herd as a whole, being on an average 7,227 pounds of milk and 335 pounds of butter per cow, but in comparing the records of different cows a great variation is shown both as to the cost and amount of butter produced, the yield ranging from 196 by the grade shorthorn Ethel to 520 pounds by the

grade Holstein Topsy, and the range in cost from 8.44 cents per pound to 3.92 cents, and averaging 6.2 cents for the whole herd. The cost to produce a pound of butter was low because the food stuffs were exceptionally cheap and also because the ration used was selected from food providing protein at lowest cost. Bran cost \$6.50 per ton, oil meal \$14 and hay \$3, while oats were 14 cents per bushel and barley 16 cents. Unfortunately such low prices very seldom obtain, and to ascertain what might be expected from the different cows when feed stuffs are 50 per cent. higher, making bran cost \$9.75 per ton, oil meal \$21, hay \$4.50, barley 24 cents per bushel, oats 21 cents, and what little other feed they received at the same rate,—the following table is submitted:

TABLE LXXV.—Showing Net Return from Each Cow.

NAME	Breed	Cost of Feed	Milk Lbs.	Butter Lbs.	Net Return
Ethel.....	Grade Shorthorn.....	\$24.81	4078	196	\$ 9.92
Shortie.....	Native.....	18.88	3870	175	11.79
Liggetta.....	Grade Shorthorn.....	30.88	6107	244	13.73
Ida.....	Grade Shorthorn.....	28.15	5866	247	15.57
Fairy.....	Grade Shorthorn.....	26.37	5237	243	16.95
Quidee.....	Holstein.....	30.63	6652	279	19.95
Belle.....	Grade Shorthorn.....	28.54	6004	274	20.44
Countess.....	Holstein.....	33.07	9644	286	22.58
Duchess.....	Jersey.....	26.83	5364	813	27.16
Lydia.....	Swiss.....	29.43	8030	322	29.42
Sweet Briar.....	Guernsey.....	33.52	6534	370	30.60
Olive.....	Grade Guernsey.....	22.12	7005	331	31.81
Topsy.....	Grade Holstein.....	47.84	11726	520	46.12
Fortune.....	Jersey.....	29.59	8346	450	48.95
Houston.....	Jersey-Guernsey.....	30.13	8797	512	58.33
Duchess 4th.....	Jersey.....	25.72	7914	493	58.78

In calculating the net return the cows are credited with 15 cents per pound for butter and 15 cents per 100 pounds of skim milk. These valuations are not exactly correct, because dairymen as a rule do not receive a net return of 15 cents for their butter taking the year through, and skim milk is only valuable in proportion to the solids it contains. The water in milk varies greatly with different breeds and different cows, and has no feeding value. In calculating the net

return from the cows Ida, Fairy and Shortie, we must take into consideration that they were charged for feed and credited for milk and butter produced during 40 weeks only. For under normal conditions such cows scarcely ever remain in milk more than that time, and they would hardly have given milk that long had they been bred to come in at the same time the year following. The record of Duchess for the first year that she was in the herd during a full period of lactation is added to the bottom of the table to show what she did under normal conditions. She, however, was in milk a whole year and gave 518 pounds of butter, but her record covers 48 weeks only, the time that she would have remained in milk had she been due to calve a year from the time she came in.

The following table is given to show what the net return from the different cows would have been had the feed been comparatively high, say, bran \$11.37 per ton, oil meal \$24.50, hay \$5.25, oats 24½ cents, barley 28 cents, and other feed in proportion. These prices are not unusual, and farmers should know what may reasonably be expected from cows under such conditions:

TABLE LXXVI.—Showing Net Return from Each Cow when Feed is Comparatively High.

NAME	Breed	Cost of Feed	Milk Lbs.	Butter Lbs.	Net Return
Ethel.....	Grade Shorthorn	\$28.94	4078	196	\$ 5.81
Liggetta.....	Grade Shorthorn.....	36.02	6107	244	8.59
Shortie.....	Native.....	22.02	3370	175	8.65
Ida.....	Grade Shorthorn.....	32.84	5666	242	12.79
Fairy.....	Grade Shorthorn.....	30.76	5237	243	12.56
Belle.....	Grade Shorthorn	33.29	6004	274	15.69
Quidee.....	Holstein.....	35.73	6652	279	14.85
Countess.....	Holstein.....	38.58	9664	286	17.07
Duchess.....	Jersey.....	31.30	5364	313	22.69
Lydia.....	Swiss.....	34.33	8030	322	24.52
Sweet Briar.....	Guernsey.....	39.10	6534	370	25.02
Olive.....	Grade Guernsey.....	31.64	7003	331	27.29
Topsy.....	Grade Holstein.....	55.23	11726	520	38.23
Fortune.....	Jersey.....	34.52	8346	450	44.02
Houston.....	Jersey-Guernsey.....	35.15	8797	512	53.31
Duchess 4th.....	Jersey.....	30.00	7914	493	54.45

It will be seen from the above table that there is a great difference in the net return made from the different cows, and that some of the cows would bring in less than the cost of keeping under conditions generally obtaining on the farm.

The cows received a balanced ration, were fed and milked regularly and comfortably housed, and yet one cow in the herd earned \$6.09 more than the combined net return from five others. When one cow will earn enough more than another to buy with the surplus a steer ready for the block, the question as to the value of the calf for meat production becomes insignificant. The true dairyman, feeding and milking dairy type cows, should have little concern as to the supply or demand for steers as feeders; for he can well afford to let those who do not care to bother with milking supply that demand from cows like the first six listed in the table.

TABLE LXXVII.—Cows Having a Tendency to Lay on Flesh.

NAME	Breed	Cost of Feed	Milk Lbs.	Butter Lbs.	Cost of 1 lb. Butter	Net Return
					Cents	
Ethel.....	Grade Shorthorn.	\$28.94	4078	196	14.76	\$5.81
Liggetta.....	Grade Shorthorn.	36.02	6107	244	14.76	8.59
Shortic.....	Native.....	22.02	3370	175	12.58	8.65
Ida.....	Grade Shorthorn.	32.44	5666	242	13.94	12.79
Fairy.....	Grade Shorthorn.	30.76	5237	243	12.65	12.56
Belle.....	Grade Shorthorn.	33.29	6004	274	12.14	15.69
Average.....		30.64	5077	229	13.38	10.37

The average cost for feed, charging for keep during the time of lactation only, is \$30.64, which is \$7.18 less than the cost of feed per year reported in Bulletin 35, showing that the charge for feed is not unreasonable. The average yield of milk was 5077 pounds, which is certainly a good yield, and is conclusive evidence that it does not follow that a cow giving "a good mess" is a profitable cow in the dairy, or will pay even for her feed. The average yield of butter was 229 pounds, which is far above the average yield of the cows as fed and handled on our farms. The cost for feed to

produce a pound of butter, not taking account of the labor, is 13.38 cents. It should be borne in mind that the time has passed when butter will bring in the markets 30 or even 20 cents per pound, and that it is only by co-operative dairying, using only the best apparatus, employing only skillful buttermakers, and then only under conditions so favorable that butter can be shipped in carload lots, that the farmer can expect to realize 15, or at best 16, cents over cost of manufacture for his butter. So, with all things favorable as to manufacture, and with scientific feeding and skillful management of this style of cow, we may get the paltry return of from half a cent to a cent and a half profit per pound for butter, being an annual net return per cow of from \$5.81 to \$15.69, and averaging \$10.37.

TABLE LXXVIII.—Cows Spare and Angular.

NAME	Breed	Cost of Feed	Milk Lbs.	Butter Lbs.	Cost of 1 lb. Butter	Net Return
Sweet Briar.....	Guernsey.....	\$39.10	6534	370	Cents 10.56	\$25.02
Olive.....	Guernsey.....	31.64	7005	331	9.55	27.29
Topsy.....	Grade Holstein.....	55.23	11726	520	10.61	38.26
Fortune.....	Jersey.....	34.54	8346	450	7.67	44.02
Houston.....	Jersey-Guernsey.....	35.15	8797	512	6.86	53.31
Duchess 4th.....	Jersey.....	30.00	7914	493	6.08	54.45
Average.....		\$37.60	6720	446	8.43	\$38.11

The average cost of feed for this group is \$37.60 against \$30.64 for the group of grade shorthorns, and 22 cents less than the cost for feed per year as reported in Bulletin 35. Yield of butter 446 pounds, being 94.7 per cent. greater than the butter from the shorthorn cows which cost 58.6 per cent. more than that from the dairy cows; the dairy type cows returning an annual profit of \$38.11, against \$10.37 from those having a beef-making heredity. Under conditions now existing, the dairy type cow can earn from two to three times as much in the dairy as can the grade beef cow.

RECORD OF THE HERD FOR THE YEAR 1896.

The time covered in this report does not in every instance have reference to the food consumed and milk and butter fat produced within the year 1896. On account of the numerous changes that occurred in the herd it was necessary in some cases, in order to give a full year's work, to include a portion of the previous year. If a cow left the herd say the 1st of November, 1896, her record commenced the same time the year previous. The feed stuffs used during the last few months in 1895 were the same as that used the last of 1896, as enough had been bought to last over the year.

During the winter months the rations were adjusted to the wants of each animal, regardless of size. A certain proportion of roughage to grain was always maintained to keep the rations properly balanced.

The feed stuffs used from the beginning of the year until the cows went to pasture, their composition and price, are given in the report for the winter of 1895-96.

TABLE LXXIX.—List of Cows in the Herd During the Year 1896, Their Age, Breeding, Time of Calving and Time of Service.

NAME	Age	Breeding	Date of Calving	Date of Service
Countess.....	10	Holstein.....	Nov. 5, 1895.....	Dec. 20, 1895
Duchess.....	5	Jersey.....	Sept. 1895.....	Dec. 18, 1895
Ethel.....	7	Grade Shorthorn.	Dec. 21, 1895.....	
Fortune.....	10	Jersey.....	Dec. 17, 1895.....	Feb. 4, 1896
Houston.....	13	Jersey-Guernsey...	Nov. 30, 1895.....	
Ida.....	8	Grade Shorthorn.	Sept. 9, 1895.....	Feb. 28, 1896
Liggetta.....	9	Grade Shorthorn.	Oct. 1895.....	
Lydia.....	6	Swiss.....	Dec. 9, 1895.....	Jan. 26, 1896
Olive.....	12	Grade-Guernsey...	Oct. 16, 1895.....	Jan. 23, 1896
Quidee.....	3	Holstein.....	Oct. 1, 1895.....	Dec. 31, 1895
Shortie.....	4	Native.....	Sept. 1895.....	Dec. 29, 1895
Sweet Briar.....	11	Guernsey.....	Oct. 5, 1895.....	Jan. 13, 1896
Topsy.....	10	Grade Holstein....	Oct. 14, 1895.....	Jan. 20, 1896

The cows were confined in their stalls while they were being fed and milked; during the day they were turned into

a covered runway where they had access to salt and water. They received no feed while they were in the runway. On pleasant days they were allowed to go into the open yard, where they could have the benefit of the fresh air and sunshine. Ten of the cows were confined in Bidwell stalls and the remainder in stanchions and box stalls while they were fed and milked. Strict regularity was observed at all times. Each cow was assigned to a certain stall and not allowed to occupy any other, which made them contented, and saved much time in caring for them. They were groomed regularly and kept clean. The stable was cleaned each morning after they were turned into the runway. Their stalls were kept bedded with fresh mill shavings, so they had no access to anything they could eat except what was weighed out to them. If straw is used for bedding they will eat some of it, no matter how well and regularly they may be fed.

The standard ration for the winter was 14 pounds of grain, 8 pounds of hay and 20 pounds of ensilage; light feeders receiving less and heavy feeders more. For instance, during February Topsy received 21 pounds of grain per day, 12 of hay and 30 of ensilage, while Olive received 12 pounds of grain, 7 of hay and 17 of ensilage. The grain was a mixture composed of bran 6 parts, barley 4, oats 3 and oil meal 1. The bran was charged at \$6.50 per ton, barley 16 cents per bushel, oats 14 cents and oil meal \$14 per ton. Prairie hay was valued at \$3 per ton, the price it cost baled at the local railway station. The ensilage from the 2d of February contained 24.04 per cent. dry matter and was valued at \$1.60 per ton. All the feed stuffs were of excellent quality. On account of the abundance of forage in the northwest, its low local market price, carbohydrates become almost as free as air and water. Every ration made up from the grains and forage grown on our farms contains carbohydrates in excess, and the problem with us is how to compound a ration so as not to have this nutrient in excess and how to provide the protein needed.

Under such conditions the digestible protein contained in our feed stuffs is a fair measure of their commercial value. At the prices quoted for bran and oil meal we secure the digestible protein in these by-products for 2.76 cents per pound. In the prairie hay it costs 2.88 cents per pound, in ensilage 4 cents, and in the roughage as used in the ration it costs 3.36 cents per pound; that is, digestible protein costs 2.58 per cent. more in the roughage than it does in the bran and oil meal. This accounts for a large portion of the ration fed to dairy cows being made up with concentrated feed. So far as our investigations have progressed no injurious effect has been discovered from such heavy grain feeding when barley, wheat, oats, peas, bran and oil meal have been used.

TABLE LXXX.—Showing Pounds of Grain Mixture Fed to the Different Cows.

1896	January	February	March	April	May	June
Countess.....	21	19	19	19	5	2
Duchess.....	13	13	13	13	2.5	2
Ethel.....	13	13	14	14	4	2
Fairy.....	14	12	12	13	5	2
Fortune.....	14	15	16	16	5	3
Houston.....	14	13	14	14	5	2
Ida.....	15	14	14	14	2	2
Liggetta.....	16	16	16	16	4	2
Lydia.....	16	16	16	16	4	2
Olive.....	12	12	12	12	3	2
Quidee.....	14	14	14	14	3	2
Shortie.....	10	10	9	8.7	2	2
Sweet Briar.....	16	16	16	16	3	2
Topsy.....	22	21	20	20	6	3

The foregoing table shows a wide range in the digesting powers of the different members of the herd, some taking more than twice as much grain as others. Only in a general way had the amount of the ration any reference to the size of the cow, that is the cows taking the large rations were large cows but some of the large cows took comparatively small rations, while the reverse was true with some of the smaller cows.

That the rations contained an unusual quantity of grain is clearly shown by the above table, and it is not strange

that they should be considered excessive by some. But those who had personal knowledge in regard to the conduct of the herd are satisfied that such was not the case, for without a single exception the food was eaten with a relish, and apparently as fully digested as usual. In some instances more feed was given than could have been utilized for milk production, but this was because of the breeding and conformation of certain members of the herd. The writer has always made it a practice to visit daily and closely inspect every animal in the division. The feed boxes and mangers are inspected at least once, and more often twice, a day. It is an easy matter to quickly detect, by the sense of smell, if any animal is not properly digesting its food.

The rations given in the table are copied from the weekly report of the stock foreman and are for the week covering the 15th of each month. It is not to be understood that the rations were not changed as to quantity, for it sometimes happened that an animal would show that it was receiving too much or too little, and in such cases the ration was increased or diminished, according to the evidences of the case. No changes, however, were made at any time other than Monday morning. No animal was off its feed during the winter.

The cows were turned into pasture the 4th of May. The grain feed was gradually reduced until June, when they received a pound morning and evening; except that Fortune received one and one-half pounds, and Topsy three pounds. No roughage was fed while they were in pasture. In August, when grass became scant, the grain was gradually increased with cows that were giving milk; the others received no feed except what they could get in the pastures. During September a little old timothy hay was fed to those in milk, and from the 1st to the 25th of October they were pastured on second growth clover. During the last week in October they were gradually broken into stall feeding, but were allowed the freedom of the yard warm nights and for a

few hours during the day. They received some odd lots of timothy and clover that had been left in the barn, for which they were charged at the rate of \$4 per ton. Enough barley, oats and oil meal was left over to last through the year. Twenty-five tons of bran was purchased at \$4.50 per ton and they were charged for bran at that rate, notwithstanding the fact that it dropped to \$3.50 the week following its purchase. The crops of 1896 were so large in the northwest that feed stuffs were so plentiful and prices so low that farmers refused to buy the mill stuffs at any price, and in many instances, in the interior, millers had to use bran for fuel in order to get rid of it.

TABLE LXXXI.—Feed Stuffs used during November and December, 1896, with Percentage of Dry Matter, Digestible Nutrients and Cost.

FOOD	Dry Matter	DIGESTIBLE			Cost Per Bu. or Ton
		Pro.	C.H.	Fat	
Timothy, Clover and Rye Hay.....	88.60	3.64	40.82	1.89	\$4.00
Corn Fodder.....	50.77	1.75	28.33	1.57	1.60
Bran.....	88.18	11.72	35.61	4.04	4.50
Barley.....	87.03	10.63	56.44	1.71	.16
Corn.....	89.30	8.12	66.45	4.00	.16
Oats.....	92.75	9.76	51.40	3.43	.14
Oil Meal.....	89.50	30.93	31.67	5.79	14.00
Timothy and Clover.....	89.50	5.26	38.38	1.88	4.00
Roots.....	17.56	1.42	14.86	.10	

From the 26th of October to the 22d of November, inclusive, the cows received bran, corn and oil meal in the proportion of 5, 6 and 1, and roots and hay in weight equal to the grain. A cow receiving 12 pounds of grain received 12 pounds of hay and 12 pounds of roots.

TABLE LXXXII.—Ration Fed from Oct. 26th-Nov. 22d.

SWEET BRIAR.

FOOD	Lbs.	D. M.	DIGESTIBLE		
			Pro.	C.-H.	Fat
Bran.....	5	4.41	.58	1.78	.20
Corn.....	6	5.34	.48	3.93	.24
Oil Meal.....	1	.89	.31	.31	.05
Hay.....	12	10.74	.63	4.60	.22
Roots.....	12	2.17	.17	1.78	.01
		23.55	2.17	12.40	.72

Digestible Nutrients, 16.37. Nutritive Ratio, 1:6.5.

The amount fed to the different cows ranged from 9 to 15 pounds of grain with roots and hay in proportion. The ration as formulated was composed of 12 pounds of grain, and as many of beets and hay, and contained 23.55 pounds of dry matter, of which 16.37 pounds were calculated as digestible, making a nutritive ratio of one of protein to six and a half of carbohydrates and fat equivalent.

TABLE LXXXIII.—Ration Fed from Nov. 23d to Dec. 27th.

FOOD	Lbs.	D. M.	DIGESTIBLE		
			Pro.	C. H.	Fat
Bran.....	10	8.82	1.17	3.56	.40
Barley.....	2	1.74	.21	1.13	.02
Corn.....	2	1.78	.16	1.81	.08
Hay.....	14	12.53	.73	5.37	.26
Roots.....	14	2.45	.20	2.08	.01
		27.32	2.47	13.45	.77

Digestible Nutrients, 17.84. Nutritive Ratio, 1:6.2.

The change in the ration was necessary because of a feeding experiment to which attention will be invited later on. The ration used the latter part of November and during December contained a trifle more protein to carbohydrates than did the one fed immediately previous. The materials used in these rations contained a larger percentage of water-free substances than was estimated, and was therefore a heavier ration than we intended to feed. The dry matter determination was not reported back until the 27th of December, when the dairy record was closed, that date falling on Sunday.

The following tables give the yield of milk and butter equivalent of each cow during the thirteen periods of four weeks, ending with her period of lactation, and totals for the dairy year, the average per cent. of fat in the milk and the average weight. Every animal in the Dairy Division is weighed each Monday morning after feeding and before watering, and the average of four weighings gives the average weight for each period. The tables are self-explanatory.

TABLE LXXXIV.—Yield of Milk in Pounds and Decimals of a Pound in Periods of Four Weeks, and Totals for the Year.

NAME	Dec. 30 Jan. 26 1	Jan. 27 Feb. 23 2	Feb. 24 to to 3	Mch 23 Apr. 19 4	Apr. 20 to to 5	May 17 June 14 6	June 15 to to 7	July 13 Aug. 9 8	Aug. 10 to to 9	Sept. 7 Oct. 4 10	Oct. 5 to to 11	Nov. 2 to to 12	Nov. 30 to to 13	Total
Countess.....	1493.5	1309.7	1228.8	1167.3	1064.0	539.5	40.9	.....	.....	280.7	1498.0	1490.3	1309.8	11412.5
Duchess.....	621.2	537.2	488.3	484.5	494.5	481.4	421.1	198.7	.....	101.7	1123.6	1026.3	923.4	6901.9
Ethel.....	866.5	698.8	491.0	418.5	367.1	337.6	293.1	199.8	129.0	24.5	.....	.....	278.9	4099.8
Fairy.....	642.2	517.9	369.7	316.1	321.0	357.5	461.5	535.8	531.1	519.2	536.5	508.8	226.8	5844.1
Fortune.....	1081.1	977.4	931.9	932.7	849.0	786.2	796.7	899.2	572.8	288.7	.....	365.7	840.1	9111.5
Houston.....	884.0	867.4	843.3	828.0	770.4	745.0	743.5	706.3	651.8	586.0	130.7	49.9	991.0	8797.3
Ida.....	599.8	541.4	542.8	548.4	573.5	581.7	583.6	492.6	474.6	364.0	307.6	534.4	570.0	6714.4
Liggetta.....	759.3	742.5	704.2	548.0	529.5	464.1	95.1	.....	.....	.....	743.1	1049.4	930.8	6566.0
Lydia.....	1074.2	953.7	841.0	819.8	830.8	849.9	732.7	600.5	497.1	77.9	.....	.....	752.7	8080.3
Olive.....	798.2	693.6	611.1	574.3	618.0	577.0	512.3	437.3	295.2	35.5	218.5	827.8	806.3	7005.1
Quider.....	706.6	672.5	649.8	617.3	606.8	566.4	485.0	298.9	11.1	90.1	696.0	590.6	661.7	6852.8
Shortie.....	385.8	317.7	292.4	306.6	365.2	410.3	338.7	193.4	6.7	52.0	880.6	852.8	767.7	5139.9
Sweet Briar.....	740.4	735.4	672.8	584.2	450.8	356.0	349.1	257.3	124.1	.....	92.6	1011.7	960.2	6364.6
Topsy.....	1233.5	1146.9	1159.1	1134.7	1002.9	880.5	825.5	675.0	166.4	50.3	1102.8	1104.3	1218.3	11726.2

* Over figures means yield for 1895.

TABLE LXXXV.—Average Per cent. Fat in Milk, Arranged in Periods of Four Weeks Each, and Average for the Year.

NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Countess.....	2.32	2.57	2.52	2.67	2.77	2.56	2.42	.....	.....	2.85	2.54	2.56	2.66	2.57
Duchess.....	4.72	4.61	5.13	5.67	5.52	5.25	5.39	5.64	.....	3.73	4.77	4.84	4.84	5.00
Ethel.....	4.29	4.03	4.18	4.24	4.05	3.88	3.85	3.99	4.01	4.98	.....	.....	4.25	4.12
Fairy.....	3.83	4.11	4.71	4.63	4.66	4.53	3.93	3.54	3.46	3.60	3.76	3.93	4.10	3.98
Portune.....	4.48	4.39	4.56	4.63	4.97	4.66	4.41	4.68	4.72	5.28	.....	5.03	4.60	4.64
Houston.....	4.83	4.98	5.04	5.29	5.33	4.80	4.69	4.82	5.22	5.65	6.14	3.51	4.51	5.00
Ida.....	3.62	3.53	3.89	4.02	3.93	3.63	3.76	4.12	4.25	4.54	3.75	3.53	3.63	3.84
Liggetta.....	3.28	3.23	3.48	3.76	3.95	3.67	3.23	.....	.....	.....	3.17	3.33	3.47	3.44
Lydia.....	2.99	3.13	3.18	3.43	3.48	3.50	3.68	3.90	4.21	5.08	.....	.....	3.32	3.44
Olive.....	3.77	3.81	4.01	4.17	4.19	4.00	4.21	4.61	4.95	5.41	4.18	3.99	3.70	4.06
Quidee.....	3.37	3.39	3.37	3.52	3.71	3.28	3.91	4.65	5.32	3.96	3.88	3.52	3.55	3.60
Shortle.....	4.35	4.61	4.94	5.01	4.86	4.52	5.30	6.43	5.87	4.08	4.62	4.45	4.42	4.70
Sweet Briar.....	4.83	4.89	4.99	5.03	5.06	4.66	4.99	5.28	5.50	.....	4.36	5.11	5.12	5.00
Topsy.....	3.71	3.65	3.65	3.60	3.95	3.75	3.92	4.83	4.21	3.40	4.02	3.76	3.77	3.81

* Over figures means record for 1895.

TABLE LXXXVI.—Yield of Butter Arranged in Periods of Four Weeks and Total for the Year.

NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Countess.....	40.40	39.31	36.12	36.04	34.42	16.10	1.15	.....	.....	9.38	44.38	44.59	40.57	342.36
Duchess.....	34.21	28.89	29.25	32.02	31.86	29.46	26.46	13.08	.....	4.42	62.46	57.96	52.15	402.22
Ethel.....	43.38	32.86	23.96	20.46	17.36	15.28	13.17	9.30	6.03	1.42	.....	.....	13.82	197.04
Fairy.....	28.67	24.84	20.33	17.06	17.46	18.88	21.15	22.15	21.44	21.78	23.56	23.36	10.84	271.52
Fortune.....	56.54	50.11	49.58	50.41	49.19	42.76	40.95	38.15	31.56	17.79	.....	20.87	45.08	492.99
Houston.....	49.78	50.37	49.62	51.07	47.84	41.74	40.66	39.75	39.68	38.63	9.37	2.22	52.11	512.84
Ida.....	25.33	22.32	24.61	25.73	26.32	24.64	25.57	23.66	23.53	19.27	13.45	22.00	24.16	300.59
Liggetta.....	29.09	28.01	28.62	24.02	24.42	19.32	3.58	.....	.....	.....	27.44	40.82	87.67	262.99
Lydia.....	37.42	34.80	31.16	33.27	33.74	34.74	31.45	27.35	24.41	4.62	.....	.....	29.19	322.15
Olive.....	35.13	30.86	28.56	27.96	30.24	26.94	25.15	23.52	17.05	2.24	10.66	38.50	34.79	331.60
Quidee.....	27.91	26.62	25.61	25.33	26.26	21.69	22.12	16.22	.69	4.17	31.53	24.26	27.39	279.60
Shortie.....	18.07	17.09	16.84	17.92	20.71	21.65	20.96	14.62	.44	2.47	47.46	44.32	39.57	282.12
Sweet Briar.....	41.68	41.94	39.18	34.28	26.59	19.37	20.33	17.70	7.96	.....	4.71	60.36	57.39	371.49
Topsy.....	53.44	48.79	49.29	47.59	46.24	38.50	37.73	34.10	8.17	3.19	51.70	48.25	53.87	520.56

* Over figures means record for 1895.

TABLE LXXXVII.—Average Weight of Each Cow Arranged in Periods of Four Weeks and Average for the Year.

NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	Average
Countess.....	1179	1184	1194	1234	1212	1282	1338	1397	1409	1366	1261	1269	1286	1274
Duchess.....	779	793	789	824	821	843	864	899	908	942	857	865	862	850
Ethel.....	1185	1145	1186	1194	1196	1210	1217	1215	1224	1242	1183	1234	1245	1203
Fairy.....	868	861	868	907	904	929	919	939	908	921	954	1009	1079	929
Purpure.....	967	960	941	939	897	871	902	952	954	954	1092	1065	1092	968
Houston.....	935	915	901	904	891	862	880	905	906	930	1007	1030	948	926
Ida.....	1137	1175	1178	1188	1192	1237	1273	1336	1327	1364	1365	1100	1104	1230
Liggetta.....	1178	1187	1209	1222	1208	1256	1310	1375	1391	1407	1332	1310	1329	1285
Lydia.....	1153	1172	1177	1202	1192	1152	1230	1262	1269	1298	1269	1239	1217	1224
Olive.....	814	826	835	836	832	832	870	884	875	880	894	821	802	848
Quidee.....	971	996	1028	1042	1032	1071	1113	1158	1148	1060	943	961	963	1038
Shortie.....	656	673	643	649	672	698	731	763	784	822	748	754	759	719
Sweet Briar.....	1066	1079	1105	1124	1119	1165	1189	1228	1227	1282	1261	1196	1215	1173
Topsy.....	1230	1246	1249	1272	1259	1364	1333	1339	1373	1434	1199	1178	1183	1274

* Over figures means record for 1895.

TABLE LXXXVIII.—Record of the Herd for the 52 Weeks Ending the Evening of December 27, 1896.

NAME	Cost of Feed	Pounds of Milk	Per cent. Fat	Pounds of Fat	Pounds of Butter	Cost of 100 Lbs. Milk	Cost of 1 Lb. of Butter Fat	Cost of 1 Lb. of Butter
Countess.....	\$27.56	11412.5	2.57	298.45	342.36	Cents	Cents	Cents
Fuchess.....	19.71	6901.9	5.00	344.76	402.22	24.15	9.39	8.05
Ethel.....	21.38	4099.8	4.12	168.89	197.04	28.56	5.72	4.90
Fairy.....	20.39	5844.1	3.98	232.73	271.52	52.15	12.66	10.85
Fortune.....	21.03	9111.5	4.64	422.66	492.99	34.89	8.78	7.51
Houston.....	21.38	8797.3	5.00	439.68	512.84	23.08	4.98	4.27
Ida.....	22.40	6714.4	3.84	257.65	300.59	24.30	4.86	4.17
Liggetta.....	23.31	6556.0	3.44	225.42	262.99	38.36	8.69	7.45
Lydia.....	23.07	8030.3	3.44	276.13	322.15	36.56	10.34	8.86
Olive.....	18.72	7005.1	4.06	284.23	331.80	28.73	8.35	7.16
Quince.....	21.61	6652.8	3.60	239.66	279.80	26.72	6.69	5.65
Shortie.....	14.43	5139.9	4.70	241.42	282.12	32.48	9.02	7.73
Sweet Briar.....	21.90	6364.6	5.00	318.42	371.49	28.07	5.97	5.11
Topsy.....	32.72	11726.2	3.81	446.19	520.56	34.40	6.88	5.90
Average.....	22.12	7454.0	4.02	299.39	349.29	27.90	7.33	6.29
						29.64	7.39	6.33

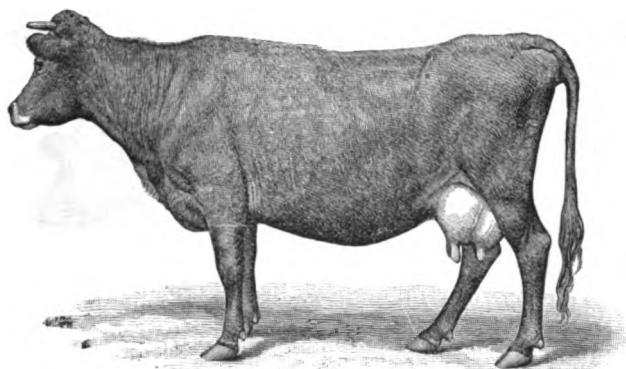
The foregoing table gives a summary of the record of the dairy herd for the year 1896. The cost of feed is what it cost to maintain each cow during thirteen periods of four weeks each, charging for feed at average prices for which the grains and roughage fed were quoted at local stations, and for mill stuffs at prices actually paid.

The average cost of feeding a dairy cow during the year was \$22.12; the average yield of milk was 7,454 pounds, which tested 4.02 per cent. fat; the yield of butter fat per cow ranged from 168.89 pounds to 446.19 pounds, and averaged 299.39 pounds. The annual yield of butter ranged from 197.04 pounds to 520.56 pounds, and averaged 349.29. The cost for feed to produce a hundred pounds of milk averaged for the year 29.64 cents. The greatest cost for a pound of butter was from Ethel, being 10.85 cents, and the least was from Houston, which was 4.17 cents. The average cost during the year to produce a pound of butter from the herd was 6 33 cents.

The yield of milk was 104,356 pounds, which produced 4,890 pounds of butter, making one pound of butter from 21.34 pounds of milk. Estimating the return to the farmer at 15 cents a pound, his receipts from the butter would be \$733.51. The value of the skim milk, if judiciously fed, would be 15 cents per hundred pounds; and assuming that the cream is one-eighth of the milk, he has left 91,312 pounds of skim milk, which at 15 cents a hundred brings \$136.97. Adding this to the receipts for butter we have a gross return from the 14 cows of \$870.48, being a return of \$62.29 per cow. Had he sold the feed in the market it would have returned him \$309.62. By marketing the feed through the cows he receives for it \$870.48, and retains on the farm a manurial value worth more in dollars and cents than the cost of the labor required to care for the cows and milk. Deducting \$309.62, the value of the feed, from \$870.48, the value of the dairy products, we have \$560.86 as the net return in one year from the 14 cows, or \$40.06

per cow. The herd returned \$2.81 worth of dairy products for every dollar's worth of feed consumed.

If the herd is divided into two groups, placing the spare cows with deep bodies in the one, and those that carry superfluous flesh in the other, their comparative value for the farmer as money makers is forcibly illustrated. The aged cow Countess, the cow Olive, spare but lacking in depth of body, and the heifers Quidee and Shortie are left out for reasons heretofore stated.



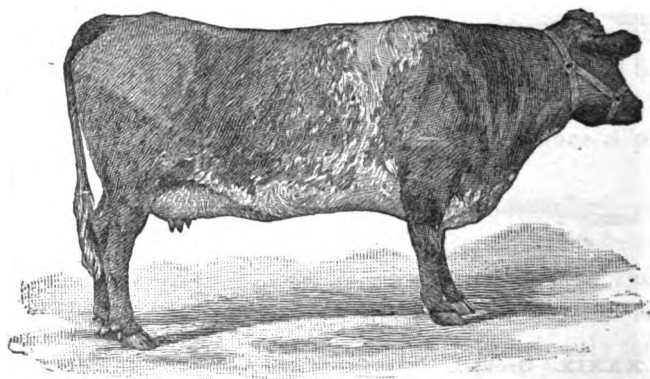
FORTUNE.

TABLE LXXXIX.—Group I.—Cows Spare and Angular with Deep Bodies.

NAME	Average Weight	Breed	Cost of Feed	Lbs. of Milk	Cost of 100 Lbs. of Milk	Lbs. of Butter	Cost of 1 Lb. Butter
Duchess.....	850	Jersey.....	\$19.71	6901.9	Centst 28.56	402.22	Cents 4.90
Fortune.....	968	Jersey.....	21.03	9111.5	23.08	492.99	4.27
Houston.....	926	Jersey-Guernsey	21.38	8797.3	24.30	512.84	4.17
Sweet Briar.....	1173	Guernsey.....	21.90	6364.6	34.40	371.49	5.90
Topsy.....	1274	Grade Holstein..	32.72	11726.2	27.90	520.56	6.29
Average.....	1038		23.35	8580.3	27.21	460.02	5.08

Taking the cows in the herd that have deep bodies through the middle and are spare and angular in conformation, we find that they produce on an average 8580.3 pounds of milk per year; that it costs, on an average, 27.21 cents for

feed to produce 100 pounds of milk; that the annual butter yield ranges from 402.22 to 520.56 pounds, and averages for the group 460.02 pounds. The cost for feed to produce a pound of butter is from 6.29 cents to 4.17 cents, and averages 5.08 cents. Of this group Houston carried the least flesh and Topsy the most. The degree of sparseness of the others is fairly and accurately indicated by the cost of production. Estimating the return for butter at 15 cents a pound and skimmed milk at 15 cents a hundred, we have a gross return per cow for the year of \$80.26. Deducting \$23.35, the cost of feed, we have a net return per cow of \$56.91.



BETHEL.

TABLE XC.—Group II.—Cows Having a Tendency to Carry Superfluous Flesh.

NAME	Average Weight	Breed	Cost of Feed	Lbs. of Milk	Cost of 100 Lbs. of Milk	Lbs. of Butter	Cost of 1 Lb. of Butter
Bethel.....	1203	Grade Shorthorn	\$21.38	4099.8	Cents 62.15	197.04	Cents 10.85
Fairy.....	929	Grade Shorthorn	20.39	5844.1	34.89	271.52	7.51
Ida.....	1230	Grade Shorthorn	22.40	6714.4	33.39	300.59	7.45
Liggetta.....	1285	Grade Shorthorn	23.31	6556.0	35.66	262.99	8.66
Lydia.....	1224	Swiss.....	23.07	8030.3	28.73	322.15	7.16
Average.....	1194		22.11	6248.9	37.8	270.86	8.02

Taking the cows in the herd that have a tendency to grow flesh, and placing them in a group, we find that they produce on an average, 6248.9 pounds of milk in a year; that it costs, on an average, 37.8 cents to produce a hundred pounds of milk; that the annual butter yield ranges from 197.15 pounds to 322.15, and averages for the group 270.86 pounds. The cost for feed to produce a pound of butter was from 10.85 cents to 7.16 cents, and averaged 8.02 cents. Of the cows in this group Ethel carried the most flesh and Lydia the least. Ethel was the only cow in the group that leaned strongly toward the beef type. Fairy, Ida and Liggetta were selected for their milking qualities and fairly represent the ideal Shorthorn milker as the record shows. Lydia, the Brown Swiss, was a fair representative of the breed, as to general characteristics, but as to milking qualities she stood above the average, judging by her conformation. She had a large frame and heavy quarters as compared with the size of her middle. Her skin was exceedingly yellow, but her milk tested only 3.44 per cent. butter fat.

Again estimating the return to the farmer for butter at 15 cents per pound and skimmed milk at 15 cents per hundred pounds, we have a gross return per cow of \$48.83. Deducting \$22.11, the cost of feed, we have a net return of \$26.72. The net return from group I. is 112.98 per cent. greater than the net return from group II.

During the five years of careful investigation in regard to the cost of production of butter between cows spare and angular in form and cows carrying considerable superfluous tissue, and having an inherited or acquired disposition to convert feed into flesh, the records show that in every instance the cow that carried the least flesh charged the least for butter, and just in so much as one cow was a little smoother and plumper than the other would her butter product cost more than the other. It should be borne in mind that the results are not made from averages where

sometimes the fleshy cow produced butter at less, but more often at greater, cost than the spare cow; but are from accumulated testimony showing not only that every day, every week, every month, but during her entire lifetime, the spare cow is the better. That she should be so much better is almost incredible, strong and uniform as the evidence is.

The cows included in the two groups ranked, with reference to the amount of tissue they carried and cost of producing a pound of butter, as follows:

	Cents.
Ethel.....Grade Shorthorn	10.85
Liggetta .....Grade Shorthorn	8.86
Fairy .....Grade Shorthorn	7.51
Ida.....Grade Shorthorn	7.45
Lydia.....Brown Swiss	7.15
Topsy .....Grade Holstein	6.29
Sweet Briar .....Guernsey	5.90
Duchess.....Jersey	4.90
Fortune.....Jersey	4.27
Houston.....Jersey-Guernsey	4.17

The vital question that confronts every dairyman in the land is, where shall the line between these cows be drawn? And before he makes the decision it will be well for him to take a few things into consideration; and the first, and most important, one is the ruling price of dairy products. Ten years ago, when the average price of butter was 26¼ cents per pound, all of the cows would do creditable service in a dairy. But when prices are such that a net return of 15 cents per pound is the average that can be expected, he must guard closely the cost of production, or the margin between cost and returns will be so close that he will be forced to the conclusion that "dairying doesn't pay." It follows, then, that, so far as profits in the dairy are concerned, the more closely he restricts his herd to cows having the typical dairy form the more certain and greater the profits. The man who is content with a net income per cow for dairy

products of from \$15 to \$25 per year will choose such cows as are found in group II. If he aspires to a net income of from \$50 to \$60 per cow he will choose such as are in group I.

The second point to be considered is the length of time the different types of cow will do service in the dairy. Our records indicate that the cows having a flesh-growing heredity, under liberal feeding, remain in the dairy only a few years, while the spare cows do good service to a ripe old age.

The cost of feed is also a matter of considerable importance. During the year 1896 feed was exceedingly cheap, bran selling at \$6.50 per ton, hay at \$3 per ton, oats at 10 to 14 cents per bushel and barley at 16 cents. Had feed ruled 50 per cent. higher, making the price of bran \$9.75 per ton, hay \$4.50, oats 21 cents per bushel, barley 24 cents, and other feed in proportion, the average annual net return from the group of grade Shorthorns would have been \$15.67, while the net return from the dairy type cows would have been \$40.24, being 156 per cent. greater than the net return from the grade shorthorns and the Swiss cow.

VARIATION IN PRODUCTIVE CAPACITY OF DAIRY COWS AND COST OF PRODUCTION.

During the autumn of 1891, a herd of cows representing various breeds was purchased by direction of the Regents of the University of Minnesota, to be used for demonstrating purposes in the stock lecture room in the School and College of Agriculture and the Dairy School, and incidentally in experimental work.

From and after the 1st day of November, 1891, every milking from each cow has been weighed and tested separately, for per cent. of fat content, and from the beginning of the year 1893 a complete record has been kept of the amount and kind of food consumed by each cow. The chemical composition of the different food stuffs used was obtained by a complete analysis of each, and ruling market prices of the different foods were noted from time to time. The object of the establishment of a complete and permanent system of records was to obtain information on every phase of animal economy that circumstances would present.

The first report made from the records was published in October, 1894, as Bulletin No. 35, Minnesota Experiment Station. The results of the first year's investigation showed that there was a great variation in the quantity of butter fat given by the different cows during the year. The smallest yield was 216.43 pounds by the grade Shorthorn Dido, at a cost for feed of \$32.13, being a cost of 14.8 cents per pound for butter fat, and the largest yield was 407.92 pounds by the grade Holstein Topsy, at a cost for feed of \$42.56, being a cost of 10.4 cents per pound for butter fat. In classifying the cows on a basis of breeds, it was found that there were good and poor cows in each class and the same was true when classified upon a basis of size. The cows were then divided into four classes or groups based upon conformation.

Group I. included those of the blocky and plump form.

Group II. included those having a less marked tendency to carry flesh.

Group III. were spare and angular in form, but lacked depth through the middle of the body.

Group IV. were spare and angular and deep through the middle from center of spine to navel.

The average pounds of butter fat yielded, cost for feed, and cost of a pound of butter fat for each of the four groups were as follows:

GROUP	Butter Fat Lbs.	Cost for Feed	Cost of 1 Lb. Butter Fat
I.....	265	87.39	Cents 14.2
II.....	273	86.00	13.1
III.....	259	86.30	14.0
IV.....	359	39.29	11.7

The total yield of butter fat from the first three groups was 2,669 pounds at a cost for feed of \$366.12, being an average of 266.9 pounds of butter fat, at an average cost of \$36.61, or 13.7 cents per pound.

Group IV. gave on an average 359 pounds of butter fat at a cost for feed of 11.7 cents per pound.

In determining the cost for feed for the year 1893 the amount actually consumed by each cow during the time she was in the barn was charged to her account, but while at pasture a uniform rate of 25 cents per week was charged, and, since cows do not all consume the same amount of food, there was an element of uncertainty in this record, and to ascertain with greater accuracy the cost of producing butter fat from the different cows a summary was made from the records for the winter 1893-94. A careful record was kept of the amount and kind of food taken by each cow, and chemical analyses made of all the feed stuffs used. The cost of feed was calculated upon the same basis as in the yearly feed record. Each milking was weighed and

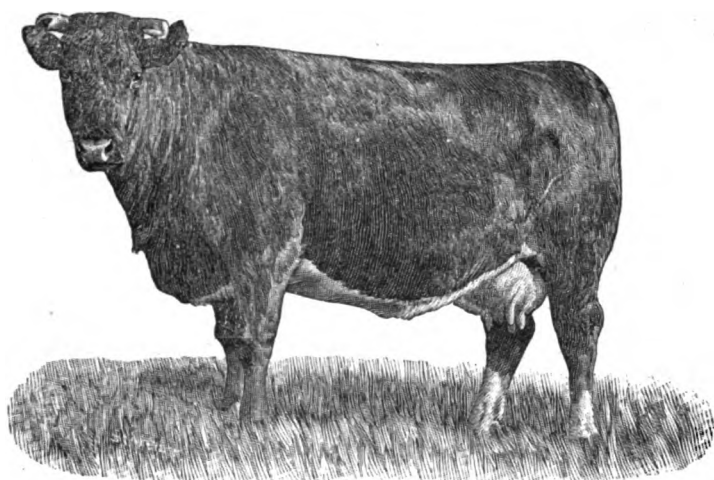
tested by the Babcock test, so the results were actual, as no estimates were resorted to in any part of the work.

The following is a summary of the results obtained during the winter of 1893-94:

NAME	Dry Matter Consumed	Dry Matter Per Day	Dry Matter per 1000 lbs. Live Weight	Butter Fat Lbs.	Dry Matter for 1 lb. Butter Fat	Cost of 1 lb. Butter Fat
Annie.....	3095.53	20.37	25.80	142.78	21.68	12.8
Beckley.....	2864.41	23.67	25.15	143.37	25.08	14.3
Bess.....	3772.88	24.60	22.04	177.19	21.29	12.3
Bettie.....	3823.37	18.86	23.33	136.75	24.30	13.8
Clara.....	3455.82	19.09	21.16	111.26	31.05	17.8
Dido.....	3452.24	18.76	14.61	106.88	32.36	18.2
Dora.....	2771.59	19.52	22.33	150.26	18.44	11.1
Fancy.....	2863.97	18.97	15.41	88.21	32.47	18.1
Gertie.....	3565.21	19.70	23.20	165.55	21.53	12.3
Houston.....	3884.53	25.73	28.24	192.69	20.16	10.8
Jennie.....	3222.39	21.34	22.09	112.91	28.58	16.6
Olive.....	3647.05	20.15	23.59	153.55	23.75	13.4
Patsy.....	3411.08	18.85	22.20	153.18	22.27	12.6
Pride.....	2890.74	19.14	24.82	136.47	21.18	12.6
Reddie.....	3823.92	21.10	21.02	156.44	24.44	13.8
Rose.....	2213.99	19.76	17.87	103.56	21.37	12.9
Rossie.....	3196.09	17.66	16.75	127.23	25.12	14.6
Roxy.....	4043.03	22.84	23.52	184.56	21.91	12.4
Sully.....	4469.19	24.69	19.96	154.45	28.94	16.4
Sweet Briar.....	4483.09	24.77	25.65	194.45	23.06	12.8
Topay.....	4005.00	23.17	20.91	199.88	20.04	12.0
Tricksey.....	3373.37	24.45	26.46	161.56	20.88	11.4

The summary of the work done during the winter showed a remarkable variation in the productive capacity of the different cows in the herd; the cost for food per pound of butter fat with Houston being 10.8 cents, while Dido charged 18.2 cents, being over 68 per cent. greater. The butter fat from the grade shorthorn Rose cost 12.9 cents, while that from the grade shorthorn Sully cost 16.4 cents. The cost of butter fat from the Jersey Beckley cost 14.3 cents per pound, while that from the Jersey Dora cost 11.1 cents. The Holstein Bess produced butter fat for 12.3 cents, while the Holstein Jennie charged 16.6 cents.

The cows were again arranged in four groups, based on conformation, assigning the beefy cows to the first, those less inclined to flesh to the second, the spare cows lacking depth of body to the third, and the spare cows with depth bodies, to the fourth, with the following result:

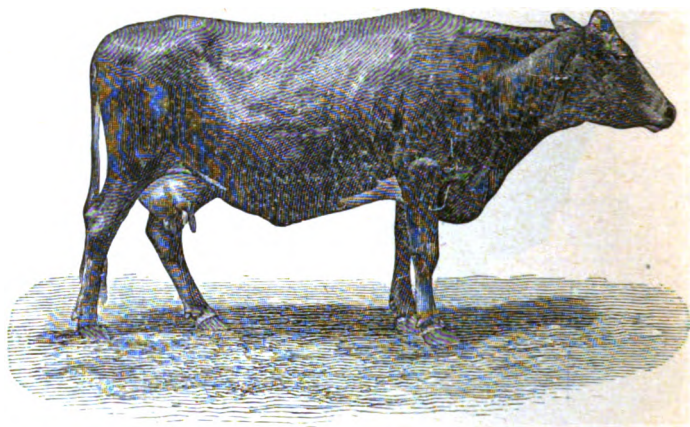


DIDO

Group I.—Beef Type, Blocky and Plump.

NAME	Weight	Breed	Lbs. Dry Matter per Day per 1000 lbs. Live Weight	Lbs. Dry Matter for 1 lb. of Butter Fat	Lbs. Butter Fat from 100 lbs. of Dry Matter	Cost of 1 lb. of Butter Fat
Fancy.....	1256	Polled Angus.....	15.41	32.47	3.08	Cents 18.1
Dido.....	1245	Shorthorn.....	14.61	32.36	3.09	18.2
Sully.....	1219	Shorthorn.....	19.96	28.94	3.45	16.4
Average.....	1240	.....	16.66	31.25	3.20	17.5

The illustrations are given to show the general conformation of the cows assigned to each group. Those in group I. had a strong tendency to lay on flesh. This was especially the case with Fancy and Dido that were blocky and well rounded, having a level top and bottom line; full in crops and thighs. Sully was less blocky in form and was less inclined to lay on flesh; she was lighter in the fore quarters than the others in the group, but carried very heavy hind quarters with straight rear line of thighs. The group returned 3.20 pounds of butter fat per 100 pounds of dry matter consumed, a pound of butter fat costing 17.5 cents. During the year their average yield was 6,384 pounds of milk and 309 pounds of butter.

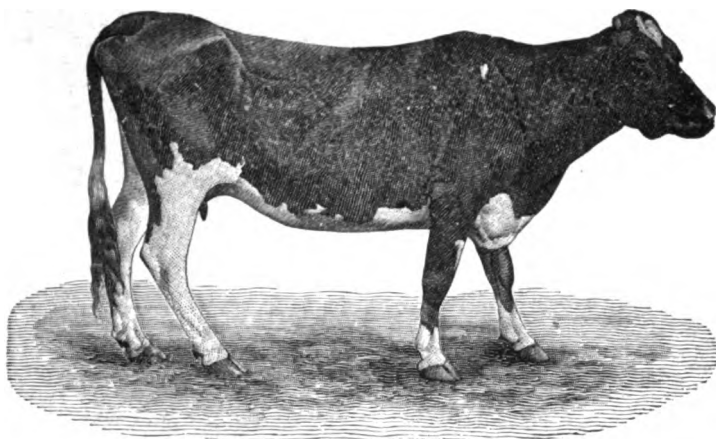


BECKLEY.

Group II.—Cows Having Less Tendency to Lay on Flesh.

NAME	Weight	Breed	Lbs. Dry Matter per Day per 1000 lbs. Live Weight	Lbs. Dry Matter for 1 lb. of Butter Fat	Lbs. Butter Fat from 100 lbs. of Dry Matter	Cost of 1 lb. of Butter Fat
Beckley.....	942	Grade Jersey.....	25.15	25.08	3.98	14.3
Clara.....	909	Grade Jersey.....	21.16	31.05	3.22	17.8
Reddie.....	1027	Grade Guernsey..	21.02	24.44	4.09	13.8
Rossie.....	903	Grade Jersey.....	18.75	25.12	3.98	14.6
Average.....	945	.....	21.02	26.42	3.82	15.1

The cows in group II. are ordinarily classed as fair dairy cows, but show a well defined tendency to carry a superfluous amount of flesh. Their hips, shoulders and sides are only medium in smoothness. This group returned 3.82 pounds of butter fat for each hundred weight of dry matter, and the food cost of a pound of butter fat was 15.1 cents. The annual yield of milk from this group was 5,467 pounds, and of butter 320 pounds.

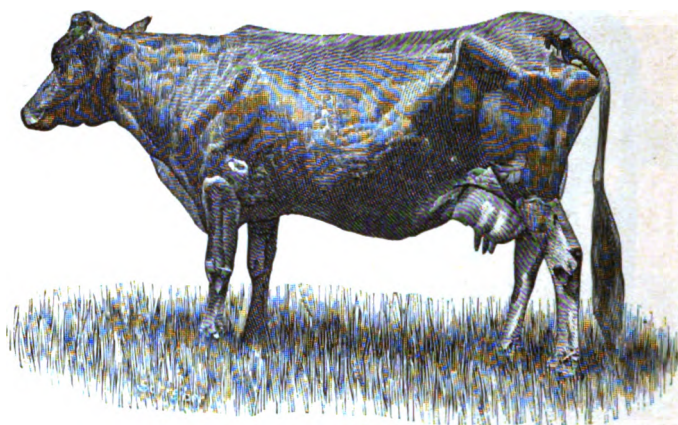


BETTIE.

Group III.—Cows Spare and Angular in Form, but Lacking Depth.

NAME	Weight	Breed	Lbs. Dry Matter per Day per 1000 lbs. Live Weight	Lbs. Dry Matter for 1 lb. of Butter Fat	Lbs. Butter Fat from 100 lbs. of Dry Matter	Cost of 1 lb. of Butter Fat
Jennie.....	1020	Grade Holstein...	22.09	28.58	3.49	16.6
Bettie.....	802	Guernsey.....	23.33	24.30	4.12	13.8
Olive.....	805	Grade Guernsey..	23.59	23.75	4.21	13.4
Average.....	875		23.00	25.54	3.94	14.6

The cows assigned to group III. were spare and angular but lacked in depth of body. This style of cow is a light feeder and has a restless disposition. She is generally described as being "leggy," but such term is not appropriate, since she has no more legs than have the cows in the other groups, neither are her legs any longer. Her body is relatively far from the ground because she is not as deep from top to bottom line as are the cows in the other groups. The cows in group III. returned 3.94 pounds of butter fat for each hundred weight of dry matter consumed, a pound of butter fat costing 14.6 cents. Their average yield for the year was 5,686 pounds of milk and 303 pounds of butter.



DORA.

Group IV.—Cows Spare and Angular, with Deep Bodies.

NAME	Breed	Lbs. Dry Matter per Day per 1000 lbs. Live Weight	Lbs. Dry Matter for 1 lb. of Butter Fat	Lbs. Butter Fat from 100 lbs. of Dry Matter	Cost of 1 lb. of Butter Fat
Annie.....	Jersey.....	25.80	21.68	4.61	12.8
Bess.....	Holstein.....	22.04	21.29	4.62	12.3
Dora.....	Jersey.....	22.33	18.44	5.42	11.1
Gertie.....	Grade Jersey.....	23.20	21.53	4.64	12.3
Houston.....	Jersey-Guernsey.....	28.24	20.16	4.96	10.8
Patsy.....	Grade Jersey.....	22.20	22.27	4.48	12.6
Pride.....	Jersey.....	24.82	21.18	4.72	12.6
Rose.....	Shorthorn.....	17.87	21.37	4.67	12.9
Roxy.....	Grade Jersey.....	23.52	21.91	4.56	12.4
Sweet Briar.....	Guernsey.....	25.65	23.06	4.33	12.8
Topsy.....	Grade Holstein.....	20.91	20.04	4.99	12.0
Tricksey.....	Guernsey.....	26.46	20.88	4.78	11.4
Average.....		23.58	21.15	4.73	12.1

The cows in group IV. embraced all the other members of the herd except the heifer Nora, that was not classified because she made considerable growth during the year. They were all spare, carried a large middle piece and were excellent feeders, consuming more food in proportion to their live weight than did the cows in the other groups. The cows in group IV. returned 4.72 pounds of butter fat for each hundred pounds of dry matter consumed, a pound of butter fat costing 12.1 cents. Their average yield for the year was 7,108 pounds of milk and 391 pounds of butter.

It appeared from a summary of this work that the cost of producing butter depended more upon the type of cow than upon breed or size; there being less variation in cost of production between cows of a certain type than was found among cows of the same breed.

Averages of the Four Groups.

GROUP	Dry Matter Eaten per Day	Dry Matter per 1,000 lbs. Live Weight	Dry Matter per lb. of Butter Fat.	Butter Fat for 100 lbs. Dry Matter	Cost of 1 lb. of Butter Fat
I	20.81	16.66	31.25	3.20	17.5
II	20.37	21.02	26.42	3.78	15.1
III	19.95	23.00	25.54	3.91	14.6
IV	21.86	23.58	21.15	4.72	12.1

It appeared from the foregoing summary that cows varied greatly both in regard to yield and cost of dairy products, and that the chief cause of this variation was due to difference in conformation. Clearly defined as was this experiment, it was deemed advisable to carry on this investigation to see if future results would show such a marked difference as was the case in the first report. There was, however, so much unusual disturbance in the herd during the year 1894 that the data obtained were not considered of sufficient value to use in this part of the work. But the record of the herd for 1895, which is given in full in this bulletin, shows that the spare cows having deep bodies yielded on an average 445.97 pounds of butter during the year, that the average cost for feed for the year was \$30.82 per cow, and that it cost for feed 6.9 cents to produce a pound of butter, while the cows that carried considerable flesh yielded, on an average, 303 pounds of butter at an annual cost for feed of \$28.21, being 9.3 cents per pound. The spare cows consumed on an average \$2.61 worth of feed more than did the cows of the fleshy type, and yielded on an average 143 pounds more butter.

It is evident that the dairy type cows could not produce that amount of butter from \$2.61 worth of extra feed, and that there must be some other cause for their greater productive powers.

The record of the herd for the year 1896 shows that it cost on an average \$22.12 for feed; that the average yield was 349.29 pounds of butter at a cost of 6.33 cents per pound. Again dividing the herd into two groups, placing the spare cows with deep bodies in the one and those having more or less tendency to smoothness in the other, it was found that the group of spare cows consumed on an average \$23.35 worth of feed, and gave, on an average, 460 pounds of butter, costing for feed 5 cents per pound. The group of cows having heavy quarters and being rather smooth in contour consumed, on an average, \$22.11 worth of feed, yielded 270 pounds of butter, costing for feed 8 cents per pound, or 60 per cent. more than the cost of butter from the spare cows. The spare cows consumed during the year, on an average, \$1.24 worth more feed, gave 190 pounds more butter at a cost of 3 cents less per pound. The blocky type cow returned an average of \$26.72 over the cost of feed, while the group of spare cows returned, on an average, \$56.91 over cost of keep, being a net return of 112.98 per cent. greater than the net return from the group of fleshy cows.

During the winter 1895-96 when the cows were being stall fed, all the feed was weighed to them, and chemical analyses made of all the feed stuffs used. It was again found that there was a great variation in the amount of dry matter consumed by the different cows per pound of butter fat produced, the variation ranging from 14.76 pounds by Houston to 30.26 pounds by the grade shorthorn Ida, and that none of the mature, spare, deep-bodied cows required as much as 22 pounds of dry matter to 1 pound of butter fat, while all the smooth, heavy-quartered cows required more than 24 pounds.

With a view of ascertaining, if possible, the reason why cows differ in productive capacity and cost of production, a record was compiled showing the amount of dry matter consumed and butter fat produced by each cow from the 10th of December to the 4th of May, 1896, when the herd was turned to pasture. The time selected is one when cows, fresh in the fall and early winter, come nearest to doing normal work, because then there is the least disturbance from exterior influences.

TABLE XCI.—Showing Pounds of Dry Matter Consumed, Butter Fat Produced, and Dry Matter Required to 1 Pound of Butter Fat by Each Cow During a Period of 18 Weeks, Ending May 3, 1896.

NAME	Breed	Dry Matter Consumed	Butter Fat Lbs.	Dry Matter to 1 lb. Butter Fat
Belle.....	Grade Shorthorn.....	3236	114	28.38
Duchess.....	Jersey.....	2781	120	23.17
Ethel.....	Grade Shorthorn.....	2905	111	26.17
Fairy.....	Grade Shorthorn.....	2744	89	30.83
Fortune.....	Jersey.....	3247	199	16.31
Houston.....	Jersey-Guernsey.....	2928	193	15.16
Ida.....	Grade Shorthorn.....	3039	95	31.98
Lou.....	Grade Holstein.....	3341	118	28.31
Lydia.....	Swiss.....	3400	180	26.15
Olive.....	Grade Guernsey.....	2579	117	22.04
Quidee.....	Holstein.....	2996	101	28.67
Sweet Briar.....	Guernsey.....	3389	147	23.06
Topsy.....	Grade Holstein.....	4514	190	23.75
Trickey.....	Guernsey.....	2847	133	21.40

In examining the record it appears that there was a great variation in the amount of dry matter consumed and pounds of butter fat yielded by the different cows during the period of 18 weeks. Olive consumed only 2,579 pounds of dry matter, while Topsy took 4,514. The grade shorthorn Fairy yielded only 89 pounds of butter fat, while Fortune yielded 199 pounds. Houston returned a pound of butter fat for every 15.16 pounds of dry matter consumed, while Ida consumed 31.98 pounds of dry matter for every pound of butter fat. The wide range in butter fat yielded by the different cows and dry matter required to produce a pound of butter fat shows that there must be one or more potent

factors bearing upon the productive powers and upon the economy of production of the cow in the dairy.

In preliminary trials in an experiment to determine the amount of dry matter required for food of maintenance by barren cows differing in size and disposition, it was found that it required from 10.84 to 12 pounds of dry matter daily for food of maintenance per thousand pounds of live weight. The cow requiring at the rate of 12 pounds of dry matter per day per thousand pounds live weight was of a restless and discontented disposition, and weighed 708 pounds; while the one requiring at the rate of 10.84 pounds of dry matter daily per thousand pounds live weight was of a quiet and contented disposition, weighing 1,079 pounds and carrying relatively more fat than did the small cow, which indicates that disposition and size, and possibly degree of fatness, have a bearing on the amount of food required for bodily maintenance.

So it follows that in hypothecating a common factor as food of maintenance there may be introduced an element of error. Such, however, is the case, to a limited extent, in all calculations bearing on animal economy. No hard and fast rule will fit each case exactly.

The calculations in the following table are based on the assumption that each cow requires 12 pounds of dry matter daily per thousand pounds live weight, for food of maintenance on the ration fed. Deducting the calculated amount required by each cow for body maintenance, the remainder is the amount each one has available for the energy required to digest that portion of her ration taken over and above her bodily needs and that available for product.

TABLE XCII.—Giving Weight of Each Cow, Dry Matter Consumed, Dry Matter Needed for Bodily Maintenance, at the Rate of 12 Pounds Daily and Thousand Pounds Live Weight, and Dry Matter Consumed per Pound of Butter Fat Produced.

NAME	Weight	Dry Matter Consumed	Dry Matter for Food of Support	Dry Matter Available for Product	Butter Fat Yielded	Dry Matter to 1 lb. Butter Fat
Belle.....	996	3236	1506	1730	114	15.17
Duchess.....	902	2781	1213	1568	120	13.06
Ethel.....	1170	2905	1769	1136	111	10.23
Fairy.....	887	2744	1341	1403	89	15.76
Fortune.....	946	3247	1430	1817	199	9.13
Houston.....	912	2926	1379	1547	193	8.02
Ida.....	1175	3089	1777	1262	95	13.28
Lou.....	1239	3341	1873	1468	118	12.44
Lydia.....	1176	3400	1778	1622	130	12.47
Oliver.....	829	2579	1253	1326	117	11.33
Quidee.....	1014	2996	1533	1463	101	14.48
Sweet Briar.....	1097	3389	1659	1730	147	11.76
Topay.....	1201	4514	1816	2698	190	14.20
Tricksey.....	863	2847	1305	1542	133	11.58

Upon this basis Houston returned a pound of butter fat for every 8.02 pounds of dry matter, while Ida required 13.28 pounds and Belle 15.17 pounds, or 7.15 pounds of dry matter more per pound of butter fat produced than was required by Houston. By deducting the calculated amount required by each cow for food of maintenance the range of variation of the amount of dry matter required to one pound of butter fat is reduced from 16.82 pounds to 7.15 pounds, showing that one of the chief causes of the difference in the productive powers of cows is the difference in the proportion of food required for bodily maintenance, and that available for product. But after making due allowance for food of support it appears that Fairy yielded one pound of butter fat for every 15.76 pounds of the dry matter available for dairy products, while Fortune returned a pound of butter fat for every 9.13 pounds, showing that for each pound of butter fat produced Fairy used 6.63 pounds of dry matter to some purpose other than milk production. Similar, but varying, results are found with the other cows listed in the table.

Upon examination of the weighing record it was found that nearly all the cows gained in weight during the period

covered by the tables. The gain actually made by each could, however, be determined only approximately because of the variation in the weekly weighings. Two cows, Fortune and Houston, made no gain, while the others gained from 20 to 80 pounds. The character of the gain made by different cows varied, as some were in calf, and others were not; some young cows made considerable growth, while the gain made by some of the mature ones included foetal growth, with others it did not. The cows Belle, Ethel and Houston were not in calf, and the heifer Quidee made rapid growth during the winter. All the other cows in the list were, as far as known, under normal condition. They were on full feed and the amount each cow could eat was determined in the early part of the winter and a fixed ratio of grain to roughage was maintained. Taking the gain in weight made by each cow and the butter fat yielded as a "Total Product" the dry matter required for a pound of product is calculated in the following table:

TABLE XCIII.—Showing Pounds of Dry Matter Consumed by Each Cow, Calculated Dry Matter Needed for Food of Support, Dry Matter Available for Product, Yield of Butter Fat, Gain in Weight, and Dry Matter Consumed to One Pound of Product.

NAME	Dry Matter Consumed	Dry Matter Needed for Food of Support	Dry Matter Available for Product	TOTAL PRODUCT		Dry Matter per Lb. of Product
				Yield of Butter Fat	Gain in Weight	
Belle.....	3236	1506	1730	114	25	12.45
Duchess.....	2781	1213	1568	120	47	9.39
Ethel.....	2905	1769	1136	111	25	8.35
Fairy.....	2744	1341	1403	89	60	9.42
Fortune.....	3247	1430	1817	199	.....	9.13
Houston.....	2926	1379	1547	193	.....	8.02
Ida.....	3039	1777	1262	96	60	8.14
Lon.....	3341	1873	1468	118	82	8.16
Lydia.....	3400	1778	1622	130	40	9.54
Olive.....	2579	1253	1326	117	20	9.68
Quidee.....	2996	1533	1463	101	80	8.08
Sweet Briar.....	3389	1659	1730	147	55	8.56
Topsy.....	4514	1816	2698	190	60	10.79
Tricksey.....	2847	1305	1542	133	40	8.91

The table shows that by making the allowance stated for food of maintenance and calculating that it requires as

much dry matter to produce a pound of gain in a cow while giving milk as it does to produce a pound of butter fat, the range of variation as to the amount of dry matter required by the different cows to a pound of product is from 8.08 pounds by Quidee, to 9.68 by Olive, or 1.6 pounds, with the exception of Topsy, and Belle that required 10.79 and 12.45 respectively; and that the chief factors that determine the adaptability of a cow for dairy work appear to be her feeding capacity, the proportion of her food needed for body maintenance and the disposition made of the nutrients available for product.

OBSERVATIONS.

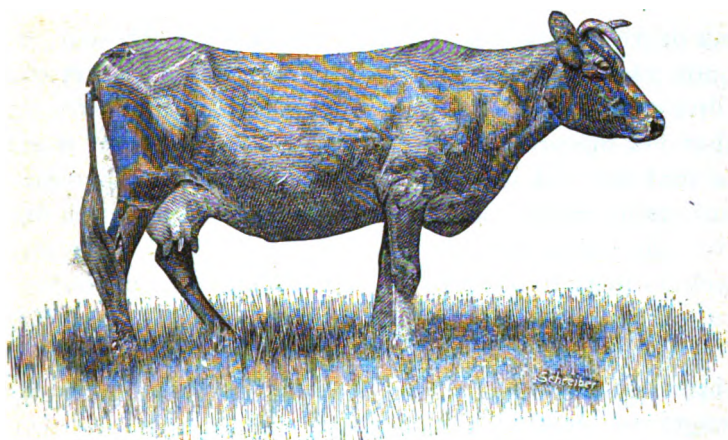
It was not expected that absolutely correct results would be obtained in every case by a hypothetical statement, even if it were in a general way correct, because animals differ in efficiency of digestion; neither is it probable that all cows require food of support at exactly the same rate, on account of difference in temperament as well as in power of assimilation. But these differences, as appears from the last table, are minor matters.

The greatest variation from the average amount of dry matter required for a pound of product was by the grade shorthorn Belle, that took 12.45 pounds, and Topsy, that required 10.79 pounds. Why these two cows required more than did the other members of the herd is a matter which cannot be definitely determined. But it so happened that Belle was employed 16 consecutive weeks in an experiment on food of maintenance, and gained on an average .2 of a pound per day on a ration containing only 11.7 pounds of dry matter, when her average weight was 1,079 pounds, being at the rate of 10.84 pounds daily and thousand pounds live weight. So it is not probable that she required more for food of support than the amount calculated. Nor can it be attributed to poor digestion, for she was employed in nu-

merous trials determining the digestibility of various food stuffs and the data obtained show she had good digestion, though not the best.

The methods of feeding were based upon the idea that a cow well and regularly fed throughout the year and from year to year would eat no more than she actually needed, and that such liberal feeding would develop both her feeding and digesting powers. But in examining the table with reference to the amount of dry matter required by the different cows for a pound of product, after deducting that required for maintenance, it appears that those that consumed relatively a large ration used nine pounds or over of dry matter; while those that required less than nine pounds consumed relatively a small ration, which indicates that some cows will eat, and apparently relish, a larger ration than they can digest and assimilate.

During the eighteen weeks covered by the table, Belle ate on an average 25.68 pounds of dry matter daily, being at the rate of 25.78 pounds per thousand pounds live weight, and returned a pound of product for every 12.45 pounds of dry matter. By referring to the following table giving her record for sixteen weeks ending May 5, 1895, it is shown that she ate daily 23 38 pounds of dry matter, which was at the rate of 20.88 pounds per thousand pounds live weight. It appears therefore that during the year she had acquired the habit of taking more feed than she could digest and assimilate. It is, however, not safe to arrive at any conclusion until all conditions bearing upon the subject are known, as will appear from the table following:



PRIDE.

TABLE XCIV.—Giving Summary of Results Obtained from December 31, 1894, to May 5, 1895.

NAME	Weight	Dry Matter Consumed	Dry Matter Consumed per Day	Dry Matter per Day per 1000 lbs. Live Weight	Dry Matter for Food of Support	Dry Matter Available for Product	TOTAL PRODUCT			Dry Matter for 1 lb. of Product
							Yield of Butter	Fat	Gain in Weight	
Beckley 2.....	849	2604	20.66	24.33	1284	1320	94	28	10.80	
* Belle.....	977	2338	20.88	22.05	1273	1065	90	15	10.12	
Countess.....	1173	3647	28.94	24.67	1774	1873	136	6	13.27	
* Dora.....	892	1751	22.74	25.49	874	877	68	25	9.47	
* Ethel.....	1083	1846	23.97	22.13	1001	845	86	.....	9.84	
Houston.....	909	3101	24.61	27.07	1375	1726	169	.....	10.23	
Lou.....	1108	3364	28.70	24.10	1675	1689	154	.....	10.98	
Lydia.....	1073	3519	27.93	26.03	1622	1897	129	40	11.25	
Nora.....	916	2758	21.88	23.89	1885	1373	60	86	9.39	
Olive.....	793	2607	20.69	26.09	1199	1408	117	.....	12.06	
Pride.....	815	2588	20.54	25.20	1232	1356	66	42	12.56	
Quidee.....	865	2909	23.09	26.69	1308	1601	113	38	10.62	
Reddy.....	756	2669	21.18	28.02	1143	1526	97	51	10.32	
Sweet Briar.....	1068	3430	27.22	25.48	1615	1815	178	.....	10.19	
Topsey.....	1157	3985	31.62	27.33	1749	2236	193	.....	11.56	
Tricksey 2.....	747	2534	20.11	26.92	1129	1405	108	32	10.00	
						24,012	1858	363	10.81	

* Belle's record is for 16 weeks, Dora's and Ethel's for 11 weeks. All the rest are for 18 weeks.

Pride, though a high type dairy cow, failed after the year 1893 to make adequate return for food consumed, and as appears from the last table required more dry matter per pound of product than any other cow except Countess. The cause of this failure, however, was not discovered until after

her death, which was at the close of her twelfth year, when quite a large number of wire nails were found in her stomach. Olive's record in both the foregoing tables indicates either that her digestion was impaired from some similar cause, or that she took more food than she could use economically, but unfortunately no examination was made of her digestive tract after she was killed. In her case, however, as well as in that of Topsy, the difficulty was probably due to eating more than could be digested and assimilated. Great as was the difference in the amount of food taken by them, both were fed about equally, taking as a basis the length and depth of their bodies.

Countess is another cow that has failed to yield butter fat in proportion to food consumed, considering her conformation, and so greatly has she deviated from what might be expected from her that it is suspected her digestive tract is impaired by the presence of some foreign substance. She has therefore not been placed in either of the groups when studying the effect of type on cost of production.

Attention is invited to the fact that during the period ending May 5, 1895, the average weight of Ethel, Lou and Lydia was considerably less than it was during the period ending May 3, 1896, and that the relative amount of dry matter required to a pound of product was less for the latter period than for the former, indicating that cows may not require food of maintenance exactly in proportion to their weight, and that in deducting food of support for the latter period, at the rate of 12 pounds daily and thousand pounds live weight, there was left less dry matter than they would seem to need for the total product returned. In making comparisons between the results obtained as appears in the two tables, it should be borne in mind that the nutritive ratio of the rations fed during the period ending May 5, 1895, varied from 1:7.1 to 1:7.3 and averaged about 1:7.2, while the nutritive ratio of the ration fed during the period ending May 3, 1896, was

1:5.3. When the wide ration was fed, 10.81 pounds of dry matter were required on an average for a pound of product, after deducting the food of support; while with the narrow ration only 9.43 pounds were used, indicating that a ration having a nutritive ratio of 1:5.3 comes nearer supplying the nutrients needed for milk production in the right proportion than does one having a nutritive ratio of 1:7.2.

EFFECTS OF LOSS IN BODY WEIGHT.

Houston maintained her weight during the period ending May 3, 1896, while Fortune lost 60 pounds. After making allowance for food of maintenance at the rate of 12 pounds dry matter per day and thousand pounds live weight, Houston returned a pound of butter fat for every 8.02 pounds of dry matter, while Fortune required 9.13, indicating that the latter either ate more food than she could assimilate or that there is no compensatory increase in yield of butter fat resulting from a loss in body weight.

During the first six weeks of her lactation, commencing in October, 1896, Duchess had an average weight of 867 pounds, and consumed 1,104 pounds of dry matter. Deducting the amount needed for food of support she had left available for dairy product 667 pounds of dry matter. During the six weeks she gave 74.50 pounds of butter fat requiring 8.95 pounds of dry matter to one pound of butter fat. During the six weeks following, her average weight was 832 pounds. She consumed 998 pounds of dry matter. Deducting 419 pounds of dry matter, the calculated amount required for food of support, she had left 579 pounds available for dairy product. During the six weeks she yielded 59 pounds of butter fat requiring 9.81 pounds of dry matter to one pound of butter fat, or 9.6 per cent. more than she required during the first period. During the first period of six weeks she maintained her weight, but during the second period she lost 49 pounds and required 9.6 per cent. more

dry matter to a pound of butter fat, indicating again that breaking down of body tissue has no compensatory return in increased yield of dairy product.

Sweet Briar came in the last of October, 1896. During the six weeks commencing November 9th, and ending December 20th, she maintained her weight, which averaged 1,215 pounds. She consumed 1,188.8 pounds of dry matter and after deducting the calculated food of support she had available 576 pounds of dry matter for dairy product. She yielded 78 pounds of butter fat, being an average of 15 pounds of butter per week, and returned a pound of butter fat for each 7.38 pounds of dry matter. During the six weeks following she lost 28 pounds, and had an average weight of 1,187 pounds. She ate 1,060 pounds of dry matter and after calculating the food of support on the basis of the reduced weight there was left available for dairy product 462 pounds of dry matter. She yielded 64.43 pounds of butter fat, being 7.17 pounds of dry matter to a pound of butter fat, or .2 of a pound less than was required during the first period when maintaining her weight; indicating that she derived a slight benefit from the decrease in body weight, or that she consumed more during the first period than she could assimilate.

Since these feeding experiments were not planned for such a close study in animal nutrition no definite results are expected from them and they are given simply to show the direction in which our investigation is leading.

JUDGING COWS BY THE TEST.

That the usefulness of a cow in the dairy cannot be definitely determined by testing her for butter fat for a week, a month, or even a year, is clearly shown by the records of the station herd. Had we attempted to pass judgment upon the merits of Ethel and Houston as indicated by the scales and the milk test during the first four weeks of any

of their periods of lactation, the evidence would have forced us to the conclusion that they were practically equal, while if judgment had been passed upon them, taking their conformation as a basis, Houston would have been declared far superior to Ethel.

Cows vary from year to year in yield of milk and butter fat, but it rarely occurs that they will give a light yield for two consecutive years as is shown by the following table:

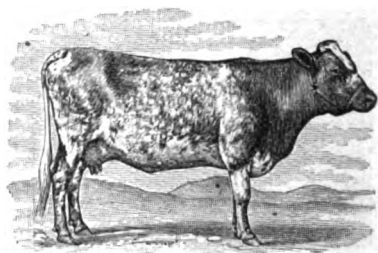
TABLE XCV.—Showing Yield of Butter for Five Consecutive Years.

	Houston	Sweet Briar	Topsy
1892.....	358	425	361
1893.....	428	417	476
1894.....	356	270	355
1895.....	404	489	554
1896.....	513	379	520

The table also shows that a cow may do exceptionally good work for two consecutive years as did Sweet Briar in 1892 and 1893, and Houston and Topsy in 1895 and 1896. But Houston was not under normal condition in 1896, since she failed to get in calf. She ate less food the last year and produced more milk and butter than she did any year previous, indicating that a cow not in calf may yield an abnormal amount of butter fat. This point was also strengthened by the performance of Lil, a roan grade shorthorn, that came to the station herd in May, 1896.

She dropped a calf the last day of May and from the 1st day of June to the 25th of October, when exclusive stall feeding commenced, she gave 5,268.1 pounds of milk containing 216.34 pounds of butter fat. During the 26 weeks following she consumed 4,537 pounds of dry matter and yielded 4,178.3 pounds of milk containing 218.69 pounds of butter fat. On the 26th day of April she was turned to pasture, and from that day until the end of May, when she completed her year's record, she gave 791.6 pounds of milk, containing 39.34 pounds of butter fat, making a total yield

for the year of 10,238 pounds of milk containing 474.37 pounds of butter fat, being equivalent to 553.43 pounds of butter. She continued in milk until October 17th, giving during her period of lactation, covering 16 months and 17 days, 12,594.7 pounds of milk containing 597.9 pounds of butter fat, being equivalent to 697.5 pounds of butter. She was in just fair working condition, weighing 1,225 pounds during the month of June when she was fresh. Her average weight during the following October was 1,197 pounds. During the first three weeks in November she received 15



LIL, GRADE SHORTHORN.

pounds of grain and the same of roots and hay, the ration containing a trifle over 29 pounds of dry matter. Noticing that she gained some 50 pounds during the three weeks when she received this ration, it was reduced to 13 pounds of grain, and by the close of the year her weight was 1,215. This weight she practically maintained and in April her average weight was 1,185 pounds. Notwithstanding the large yield during the period of lactation, there is nothing extraordinary about it, when all the conditions are taken into account. She was a fair feeder, having a capacity of 25 pounds of dry matter per day, being at the rate of 20.75 per thousand pounds live weight. Not being in calf, having a contented disposition and not laying on any flesh, all her food above that needed for body maintenance was available for dairy product. June, July and August the pasture was

excellent, and during that time she did not seem to care for more than 4 pounds of grain daily. From the 1st of September her grain ration was gradually increased and by the end of October she was again on full feed. She was in milk 504 days and since she required in round numbers 25 pounds of dry matter daily during the winter when she was far advanced in her period of lactation it is not unreasonable to assume that she consumed 26 pounds daily during the first six months of her lactation and 25 pounds daily during the remainder of the term, which amounts to 12,783 pounds of dry matter. A cow of Lil's disposition uses the minimum for food of maintenance, being in round numbers 14 pounds of dry matter daily for a cow weighing 1,200 pounds, amounting to 7,056 pounds for 504 days, leaving available for dairy products 5,727 pounds. She yielded 697 pounds of butter which is 1 pound of butter for every 8.21 pounds of dry matter, being the amount ordinarily required by cows not taking more feed than they can assimilate and having good digestion. To test her digesting powers she was employed in a digestion experiment during three weeks in November, the feed being fodder corn, roots and oil meal. She digested 70 per cent. of the dry matter while the cow Lottie, that was on a similar experiment, digested only 62.25 per cent. of the dry matter.

Her largest yield in any one week was only 12.37 pounds of butter, and after being in milk six months she was still giving 11.5 pounds per week. Had she been in calf and due in about a year from the time she dropped her calf, she would probably have given milk about 40 weeks and yielded about 400 pounds of butter, which would have been a most excellent record, but not being in calf, nor using any food for gain in weight, she was enabled to yield 553 pounds in 12 months and 697 pounds in 16 months and 17 days.

As further evidence showing what little significance attaches to a single year's record the performance of the grade shorthorn Fairy is cited. During the year 1896 she gave

271 pounds of butter. In 1897 her yield was 384 pounds and in 1898 it was 216 pounds. And yet during the three years she had practically the same care and similar methods of feeding obtained.

From the time the dairy herd was established there has been no effort made to stimulate or train a cow to produce an abnormal yield for a week, a month or a year; so the variations that occurred in this respect were due simply to the variation in the physical tone of the cows. It is not certain that the cows were fed in such a way that the greatest yield possible was obtained. The fact that Topsy produced 554 pounds of butter in a year, Lil 553, and Houston 512, with only ordinary feed and under such disadvantages as exist at a public institution like an experiment station, indicates the possibility of far greater yields when all conditions are favorable. It may be that a cow in the best possible physical condition and having extraordinary feeding powers might digest 30 pounds of dry matter daily. With a large middle and light quarters and weighing only a thousand pounds she would require 4,380 pounds of dry matter during 365 days for food of maintenance. If she made no gain in weight and had no foetal growth to nourish, she would have available for milk production during the year 6,570 pounds of dry matter. Calculating a yield of one pound of butter from eight pounds of dry matter an annual yield of 800 pounds of butter, or of milk 25,000 pounds containing 2.8 per cent. butter fat, would seem within the range of probability. The tables indicate that if a narrower ration containing a smaller percentage of inert matter were provided the amount of dry matter required for food of support and for a pound of butter might be materially reduced. The records show that under our system of feeding it required from 8 to 9.6 pounds of dry matter over and above that calculated for food of maintenance to produce a pound of butter by cows under normal condition.

During the year that Houston made her best record, which was 512 pounds of butter, she consumed only 23 pounds of dry matter daily during the first six months of her period of lactation. Her average weight during the year was 926 pounds, and calculating that she required 11 pounds of dry matter daily for food of maintenance she had 12 pounds left daily available for dairy product, being enough for one and a half pounds of butter. Had she been milked 365 days her normal yield under the conditions would have been 547 pounds. It is not certain that the ration fed provided the nutrients required for bodily maintenance and milk production in the exact proportion needed, neither is it claimed that the ration was one that required the minimum amount of energy for digestion. It may be possible, therefore, that in cases where these requirements are fully met the amount of dry matter required for the production of a pound of butter may be considerably lessened. It has been shown that cows vary from year to year in physical tone; that at some time in their life they will consume more food and do more work than they have done at any other time; and that the usefulness of a cow cannot be measured by any one year's performance. Every living thing reaches its meridian of life but once, and if at that time all conditions are favorable and every opportunity is offered, extraordinary results may be obtained.

COMPARING THE COST OF BUTTER AND MEAT PRODUCTION.

During the winter of 1896-97 an experiment was made having for its object a comparison of the cost of butter and meat production. During the summer of 1896 the Division of Agriculture used four steers in an experiment in pasturing on plots of forage crops. The preliminary work was completed in the fall, and the steers were to be fattened, and in the meantime used during the winter in class work, and later on were to be slaughtered, and the dressed meat used in the co-operative dining hall connected with the School of Agriculture.

It was decided that the steers should be turned over to the Dairy Division for the experiment stated.

The experiment was divided into two periods of five weeks each. The first period the cows and steers received a ration composed of six parts ground corn, five parts bran and one part oil meal, with timothy hay and beets. During the second period they received a grain mixture composed of eight parts bran, two of corn and two of barley. The first two weeks were set aside for preliminary feeding and the remaining three weeks of each period were taken for the experiment proper.

Three of the steers were about thirty months old, and one three or four months younger. Two were black, and had the appearance of carrying some Angus blood; two were red, and evidently had some ShortHorn blood. Weight of steers ranged from 830 to 1,008 and in general conformation two would be considered as fair steers for feeding purposes, while two would be called poor.

The cows selected for the experiment were above the average in quantity of milk and butter produced, but in cost of production two of them, Countess and Liggetta, were

among the highest in the herd; while Sweet Briar and Duchess were below the average, but not the lowest.

FIRST PERIOD.

TABLE XCVI.—Showing Feed Consumed and Gain Made by Each Steer During the First Period of the Trial, When the Grain Ration was Composed of a Mixture of Six Parts Corn, Five Parts Bran and One Part Oil Meal.

NAME	Days in Trial	FEED			Gain Lbs.
		Hay	Grain	Roots	
Bob.....	21	252	252	252	56
Ole.....	21	252	252	252	32
Cal.....	21	231	231	231	40
Nig.....	21	210	210	210	30
Total.....	84	945	945	945	158

Nine hundred and forty-five pounds of the grain mixture with an equal amount in weight of hay and sugar beets produced a gain of 158 pounds, or 100 pounds of the grain mixture with an equal weight of roots and hay produced 16.72 pounds of gain.

TABLE XCVII.—Showing the Amount of Feed Consumed and Butter Produced by the Four Cows in the Experiment During the First Period of the Trial, When the Grain Ration was Composed of a Mixture of Six Parts Corn, Five Parts Bran and One Part Oil Meal.

NAME	Days in Trial	FEED			Lbs. of Butter
		Hay	Grain	Roots	
Countess.....	21	343	343	343	34.06
Duchess.....	21	294	294	294	47.87
Liggetta.....	21	322	322	322	31.67
Sweet Briar.....	21	280	280	280	45.33
Total.....	84	1239	1239	1239	158.93

One thousand two hundred and thirty-nine pounds of the grain mixture, together with an equal amount, in weight, of hay and roots, produced 158.93 pounds of butter or 100 pounds of the grain mixture with an equal amount, in weight, of hay and roots, produced 12.66 pounds of butter.

SECOND PERIOD.

TABLE XCVIII.—Showing Feed Consumed and Gain Made by Each Steer During the Second Period of the Trial and When the Grain Mixture was Composed of Eight Parts Bran, Two Parts Corn and Two Parts Barley.

NAME	Days in Trial	FEED			Gain Lbs.
		Hay	Grain	Roots	
Bob.....	21	252	252	252	80
Ole.....	21	189	189	189	57
Cal.....	21	210	210	210	75
Nig.....	21	189	189	189	54
Total.....	84	840	840	840	266

Eight hundred and forty pounds of the grain mixture, together with an equal amount each in weight of roots and hay, produced 266 pounds of gain, or 100 pounds of the grain mixture with an equal amount in weight of hay and roots produced 31.66 pounds of gain.

TABLE XCIX.—Showing the Amount of Feed Consumed and Butter Produced by the Four Cows in the Experiment During the Second Period of the Trial, the Grain Ration Being a Mixture of Eight Parts Bran, Two Parts Corn and Two Parts Barley.

NAME	Days in Trial	FEED			Lbs. of Butter
		Hay	Grain	Roots	
Countess.....	21	352	352	352	30.77
Duchess.....	21	273	273	273	40.25
Liggetta.....	21	315	315	315	28.36
Sweet Briar.....	21	315	315	315	43.95
Total.....	84	1255	1255	1255	143.33

Twelve hundred and fifty-five pounds of the grain mixture, together with an equal amount in weight of hay and roots, produced 148.33 pounds of butter, or 100 pounds of the grain mixture and an equal amount in weight of hay and roots produced 11.42 pounds of butter.

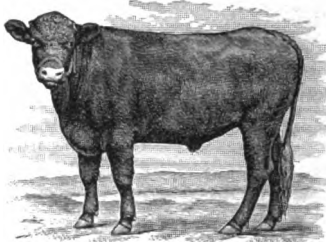
TABLE C.—Giving Summary of Results Obtained in the Two Periods.

COWS					STEERS				
Period	Hay Lbs.	Grain Lbs.	Roots Lbs.	Butter	Period	Hay Lbs.	Grain Lbs.	Roots Lbs.	Gain
1... ..	100	100	100	12.66	1.....	100	100	100	16.72
2.....	100	100	100	11.42	2.....	100	100	100	31.66
Total..	200	200	200	24.08	Total..	200	200	200	48.38
	100	100	100	12.04		100	100	100	24.19

Combining the results obtained during the first and second periods we find that 100 pounds of grain mixture with an equal amount of hay and roots when fed to the four steers produced 24.19 pounds in gain and that an equal amount of the same food fed to the four cows produced 12.04 pounds of butter.

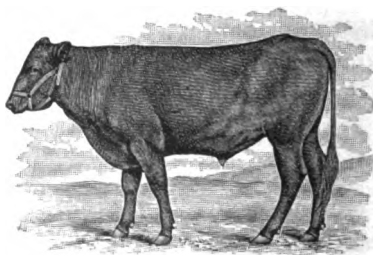
The foregoing comparisons are made with reference only to the amount of feed consumed by the four steers and four cows to produce meat and butter products, and since all the feed was weighed and chemical analyses made of the different feed stuffs used, also a digestion experiment made with the four steers at the close of the experiment proper, further comparisons can be made as to the amount of dry matter consumed by the eight animals employed in the experiment, the cost of butter and meat production, the pounds of dry matter required to produce a pound of butter and a pound of gain, and with the steers the amount of food digested by each, and approximately what disposition was made of the food.

The steers represented four clearly defined types, though none of them fairly represented what would be termed an excellent beef form.



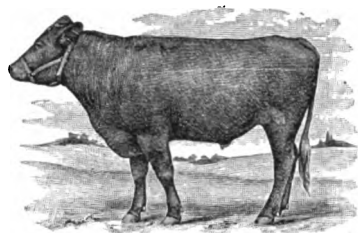
BOB.

Bob had good depth through the middle which is an indication of a good feeder; he had excellent heart girth, was low in the flank, medium breadth across the shoulders, crops medium full, ribs well sprung, thighs fairly thick, with rear thigh line running down nearly straight. He was very quiet in disposition, slow in his movements, paying little attention to what was going on and spent much of his time lying down. He consumed the most feed, made the greatest gain of any of the steers and made it at the least cost. His average daily gain was 3.24 pounds at a cost for feed of $1\frac{1}{4}$ cents per pound of gain.



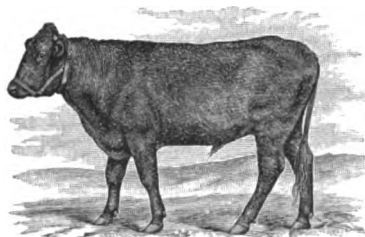
CAL.

Calamity was black and hornless; medium in depth through the middle; light fore and hind quarters; cut up high in the flank; hook points prominent; withers, back and rump quite sharp; thighs flat and a little incurving. Bright; quick eye, rather timid, and just a little light in feeding capacity. His average daily gain was 2.74; cost of a pound of gain 1.82 cents.



OLE.

In a general way Ole resembled Bob, being red and similar in conformation but not quite as deep in body. He had a large head, was heavy in bone, large limbs and heavy tail. His fore quarters were fully as broad and full as Bob's, but his hind quarters were a trifle more narrow and angular. In disposition he differed greatly from the others. He was slow in movement but restive and stubborn, and while he was not as timid as Cal. he was much slower in responding to kind treatment and in becoming reconciled to confinement. His average daily gain was 2.12 pounds, at a cost of 2.37 cents per pound.



NIG.

Nig, as the name indicates, was black and evidently carried some Angus blood. He was smaller than the others, weighing 830 pounds when he came to the division, but was taller than his weight indicated. His most noticeable characteristic was a lack of depth and breadth of body, which gave him a leggy appearance. There was nothing remarkable in his disposition, being just fair in this respect. He gained on an average 2 pounds per day and it cost 2.26 cents per pound of gain.

TABLE CI.—Summary of Results on Meat Production.

NAME	Dry Matter Lbs.	Cost of Feed	Gain Lbs.	Average Daily Gain	Cost of 1 lb. of Gain	Dry Matter to 1 lb. of Gain
Bob.....	981.96	\$2.40	136	3.24	Cents 1.76	7.22
Ole.....	858.90	2.11	89	2.12	2.37	9.65
Cal.....	858.89	2.10	115	2.74	1.83	7.46
Nig.....	777.00	1.90	84	2.00	2.26	9.25
Total.....	3476.55	8.51	424	.....	.....	.....
Average.....	.....	.....	.....	2.52	2.01	8.20

The four steers consumed \$8.51 worth of feed, gained 424 pounds; the average daily gain was 2.52 pounds; cost for feed per pound gain 2 cents, and it required 8.2 pounds of dry matter for every pound of gain.

The following table gives the pounds of dry matter consumed by each cow, the cost of feed, the yield of butter, cost of a pound of butter and the dry matter required to produce a pound of butter:

TABLE CII.—Summary of Results on Butter Production.

NAME	Dry Matter Lbs.	Cost of Feed	Yield of Butter Fat Lbs.	Yield of Butter Lbs.	Cost of 1 lb. of Butter	Dry Matter to 1 lb. of Butter
Countess.....	1349.04	\$3.29	55.35	64.58	Cents 5.09	20.89
Duchess.....	1103.76	2.70	72.10	84.12	3.21	13.12
Liggetta.....	1240.05	3.03	51.45	60.03	5.05	20.66
Sweet Briar.....	1158.50	2.82	76.52	89.27	3.16	12.98
Total.....	4851.35	11.84	255.42	297.99	.....	.....
Average.....	.....	.....	.....	.....	3.97	16.28

The four cows consumed \$11.84 worth of feed, produced 255.42 pounds of butter fat, being a butter equivalent of 297.99 pounds, at a cost of 3.97 cents, consumed 16.28 pounds of dry matter to one pound of butter; while the four steers gained on an average 2.52 pounds per day, costing two cents per pound of gain, and required 8.2 pounds of dry matter to one pound gain in weight.

As there will always be some variation as to cost of production, both for butter and meat, and the amount of dry matter required to produce them, it is not expected that this experiment will do more than to give the comparative cost, and on this point we shall deal only in round numbers, and show that on an average it required half as much feed to produce a pound of gain or growth as it did to produce the milk that would make a pound of butter. The amount of dry matter required to produce a pound of either product was exceptionally small because of the short time covered by the experiment. Had it been carried on for six months the average cost for gain and butter product and the amount of dry matter required for their production could have been accepted as a fair average and a standard.

The following table gives the records of the four cows during the remainder of the winter, covering a period of 26 weeks, during which time the average cost of feed for a pound of butter was 4.76 cents, and a pound of butter was produced for each 17.71 pounds of dry matter consumed.

NAME	Dry Matter Lbs.	Cost of Feed	Butter Lbs.	Cost of a Pound of Butter	Dry Matter to 1 lb. of Butter
Countess.....	5353.88	\$14.88	255.64	Cents 5.83	20.94
Duchess.....	4148.83	10.71	280.77	3.81	14.78
Liggetta.....	4794.44	13.28	221.58	5.99	21.64
Sweet Briar.....	4493.09	11.70	302.84	3.86	14.84
Average.....				4.76	17.71

WHY THE DIFFERENCE IN PRODUCTIVE POWERS.

Referring to table CI., Summary of Results on Meat Production, it will be seen that there was a marked difference in the gain made by the different steers, the cost of the gain, and the amount of dry matter required to produce a pound of gain; Bob making a pound of gain with 7.22

pounds of dry matter, Cal. requiring 7.46 pounds, Nig 9.25, and Ole 9.65. The cost of producing a pound of gain was exactly in proportion to the amount of dry matter required. The question that interests every farmer is why this difference in the gain and cost of gain with the different steers. The description of the steers gives only a partial explanation of the difference in the manner in which they responded to the feed. But so far as the description affords evidence, Ole should have made a better return than Cal., for the latter was of a more restless disposition and was not of as good a beef type. Each took the same amount of feed and carried practically the same weight during the experiment and yet, Cal gained 115 pounds while Ole gained 89 pounds. Had each steer made gain in proportion to the dry matter consumed, taking the gain made by Bob as a basis, Cal. and Ole would have gained 119 pounds each and Nig would have gained 107 pounds. Immediately after the close of the experiment and before any change was made in their feed an investigation was made to determine the per cent. of the feed that each steer digested. The feed was carefully weighed as during the experiment and chemical analyses made of the different feed stuffs to ascertain the exact amount and kind of nutrients that each steer consumed; the excreta were weighed and analyzed to determine the amount of nutritive substances that were digested by each.

TABLE CIII.—Giving Pounds of Dry Matter Consumed, Per cent. Digested, and Pounds of Dry Matter Digested.

NAME	Dry Matter Consumed Lbs.	Per cent. Dry Matter Undigested	Per cent. Dry Matter Digested	Dry Matter Undigested Lbs.	Dry Matter Digested Lbs.
Bob.....	981.96	29.10	70.90	285.75	696.21
Cal.....	858.69	22.44	77.56	192.69	666.00
Ole.....	858.90	27.51	72.49	236.29	622.61
Nig.....	776.00	30.15	69.85	233.87	542.13

There was a marked difference in the digesting powers of the four steers, the range being 77.56 against 69.85 per cent. Bob consumed 123.27 pounds more feed than did Cal. but digested only 30.21 pounds more. Cal. and Ole received 858 pounds of dry matter each, but the former digested 666 pounds, while the latter digested only 622.61 pounds; or in other words Cal. found 43.39 pounds more of nutritive substances available for gain. Another point worthy of note is the fact that Cal. with a medium ration digested his food the best, but Ole being of equal weight and getting the same ration digested 5 per cent. less. Bob receiving a heavy ration digested 1 per cent. more than did Nig with a light ration.

Had the four steers gained in proportion to the nutrients digested by each, taking the gain made by Bob as the basis, Cal. would have gained 130 pounds, Ole 121 and Nig 106, but the three steers fell short of this, Cal. by 15 pounds, Ole by 32 pounds and Nig by 22 pounds. Since these calculations are based upon the amount of feed actually digested it follows that a part of the nutritive substances were diverted by three of them to some purpose other than gain. When three steers in forty-two days make no return for nutrients that should produce 69 pounds of gain, under such apparently favorable conditions, the *why* becomes a matter of considerable importance.

The first point to be considered is the amount of food each steer required for bodily maintenance. It has been stated that Bob was of a quiet disposition, contented as to his surroundings as long as he had all he wanted to eat and was comfortable. An animal with such a disposition uses the minimum amount of food to repair waste tissues and furnish the energy needed to keep all the organs in normal working order. Bob will therefore be made the basis for comparison.* It is indicated that with an animal under fairly normal condition—neither fat nor poor—in comfortable quarters, and contented, six pounds of digestible

*Food of maintenance experiment not yet published.

matter of the food stuffs ordinarily used will maintain a thousand pounds of live weight for 24 hours. The additional amount required to provide the muscular energy needed to digest a full ration is an unknown factor and will be left, in common with the factor of the amount of digestible nutrients needed for a pound of gain after the food of maintenance is provided for.

Taking the actual amount of food stuffs digested daily by each steer the gain made, as near as could be determined by the scales, and assuming that three pounds of nutritive substances were used by each steer for each pound of gain and for the extra energy employed to digest a full ration, we have the following table:

TABLE CIV.—Showing Disposition Made Daily of the Nutrients Digested by Each Steer.

	Bob	Cal	Ole	Nig
Pounds of Nutrients Daily.....	16.57	15.85	14.82	12.94
Pounds of Nutrients Needed for Gain.....	9.72	8.22	6.36	6.00
Pounds for Food of Support.....	6.85	7.63	8.46	6.94
Per 1000 Pounds Live Weight.....	6.00	7.23	8.04	7.71

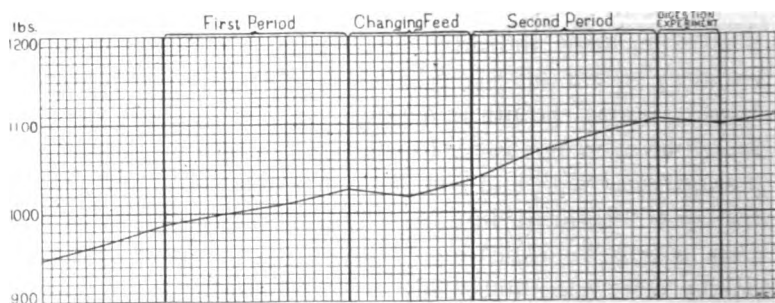
The average weight of the steers during the experiment was: Bob, 1,141; Cal., 1,055; Ole, 1,052, and Nig, 900. Their average daily gain was: Bob, 3.24; Cal., 2.74; Ole, 2.12 and Nig 2 pounds. The amount of nutrients apparently required daily by each steer is in accord with the disposition peculiar to each. Bob, the docile, required the minimum, being 6 pounds; Cal., the timid, used 7.23; Ole, the restive, 8.04; and Nig 7.71. Had not special notice been taken of the disposition peculiar to each, and the per cent. of food digested by each carefully ascertained, we should be at a loss to account for the discrepancy between the gain made by Cal. and Ole, since each was of the same average weight during the experiment, consumed the same amount of food; but when it is shown that Cal. found 1.04 pounds

more nutrients available for gain daily than did Ole, that this represents a trifle over half a pound of gain per day, and that during the experiment it would amount to an increase in gain of 22 pounds, the balance of this discrepancy in gain, which is only four pounds, may be attributed to the difference in disposition. A careful study of the tables in connection with the illustrations and the description given of the four steers will show that good disposition and digestion are important factors in deciding the usefulness of a steer. Cal. was not what would be called, ordinarily, a good steer, but being a fair feeder, having excellent digestion and being of a tractable disposition, he was enabled to gain 26 pounds more than Ole, notwithstanding the fact that in conformation Ole more nearly resembled Bob. The experiment indicates, incidentally, that large feeding capacity, good digestion and a good disposition are the three essential points in a good steer. Of these, Bob possessed two, being a large feeder and having a most contented disposition. Cal. had only one, in a marked degree, which was good digestion, but as to quantity of food that he could take he was only medium. Ole's digestion and feeding capacity were medium, while his disposition was not good. Nig was a trifle better in disposition but lacked both in feeding capacity and digestion.

To illustrate what effect a change of feed, or any disturbance, may have on animals even when more than ordinary precaution is taken to reduce it to a minimum, a diagram is submitted showing the average weight of the four steers every Monday morning during the experiment:

The base line of the chart represents the 900 pound line. The two other heavy horizontal lines represent the 1,000 pound line and the 1,100 pound line, respectively. The upper line represents the 1,200 pound mark. While the small squares horizontally, represent days and vertically 10 pounds. The line traced represents the gain or loss in weight of the steers.

It will be noticed that the steers made steady and quite uniform gain until the close of the first period, when the grain ration was changed from one composed of a mixture of 6 parts corn meal, 5 parts bran and 1 part oil meal to one composed of 8 parts bran, 2 of corn and 2 of barley, the



roughage remaining the same. At the close of the first period the average weight of the four steers was 1,026 pounds, while at the close of the first week when the feed was changed they weighed on an average 1,018 pounds, being a loss in weight of 8 pounds. Nothing occurred, so far as is known, that should in any way disturb the steers, except the change of food. During the second week, however, they regained their normal weight, and gained at the rate of 4.7 pounds each. During the three weeks covered by the second period they gained, on an average, 67 pounds, being average daily gain of 3.19. During the week following, a digestion experiment was carried on with the four steers. They received the same feed that they had during the three

weeks preceeding, but on account of the disturbance occasioned by the presence day and night of two attendants, they not only made no gain, but lost 5 pounds per head. They took the feed regularly and seemingly with a relish and an analysis of the dung and urine showed that their digestion was normal. Yet, during the week Bob and Cal. lost 2 pounds each, Ole lost 5 and Nig 10.

An additional week is added to the chart to show that during the week following the digestion experiment they again gained, but only at the rate of 1.4 pounds per day.

The experiment shows that:

1. With 100 pounds of grain and an equal amount of hay and roots, four steers made a gain of 24.19 pounds, and four cows with the same amount and kind of feed produced 12.04 pounds of butter.

2. The four steers consumed feed valued at \$8.51, gained 424 pounds, being an average daily gain of 2.52 pounds, costing 2 cents per pound and returning a pound gain for 8.2 pounds of dry matter consumed.

3. The four cows consumed feed valued at \$11.84, yielded 255.42 pounds butter fat, being a butter equivalent of 297.99 pounds at a cost for feed of 3.97 cents per pound, producing a pound of butter to 16.28 pounds of dry matter consumed.

4. Type has not so much significance with a steer as it has with a dairy cow for the reason that a steer not of good type may be a large feeder and a good digester and convert all the food taken over his needs for maintenance into gain; while a cow not of the dairy type has the alternative of converting food either into milk or gain, and she may choose the latter at a time when the owner wants only the former.

5. Any sudden change in feeding or handling may cause a loss in weight or shrinkage in yield of milk and butter fat.

VARIATION IN FLOW AND PER CENT. OF FAT IN MILK.

Keeping an accurate record of the daily yield of milk, and testing each milking separately, since the establishment of the dairy herd of the Minnesota Experiment Station, has afforded a good opportunity to note the changes that take place in the flow and quality of the milk from each cow, and the influence that feed has on milk secretion.

In the management of the herd, it has been the aim always to supply the nutriment needed for normal milk production, and whenever it was found necessary to make any change in feed it was made gradually, to avoid, as much as possible, any abnormal shrinkage, and since no experiment was planned specially with a view of studying the effect that different feed stuffs have on the secretion of milk, no definite results have been obtained, and the data submitted are simply such as have accumulated incidentally.

To show how much a cow may vary in milk yield and fat content from one milking to another during a week Topsy's record for the week ending January 28, 1896, is given:

TABLE CV.—Showing the Yield of Milk and Per Cent. Fat of each Milking for One Week.

1896			Milk	Per Cent. Fat	Total Fat
January	22.....	A. M.	28.2	4.2	.98
"	22.....	P. M.	21.0	4.1	.86
"	23.....	A. M.	21.9	3.7	.81
"	23.....	P. M.	21.6	3.9	.84
"	24.....	A. M.	21.5	3.5	.75
"	24.....	P. M.	20.7	3.8	.78
"	25.....	A. M.	21.7	3.6	.79
"	25.....	P. M.	18.6	3.8	.72
"	26.....	A. M.	23.5	3.8	.90
"	26.....	P. M.	20.3	4.2	.86
"	27.....	A. M.	21.5	3.5	.76
"	27.....	P. M.	21.5	3.5	.76
"	28.....	A. M.	22.0	3.0	.66
"	28.....	P. M.	21.0	4.4	.92

The week's record shows that the lightest yield of milk was 18.6 pounds on Thursday evening and the greatest yield Friday morning, while Sunday morning January 28th her milk contained 3 per cent. fat and in the evening it contained 4.4 per cent. fat.

To show how a cow's milk may vary in quality during the first four weeks of her period of lactation the following record of Fairy, a grade shorthorn, is given:

TABLE CVI.—Showing Yield of Milk and Per Cent. Fat for Four Consecutive Weeks.

FIRST WEEK.

Day in Lactation	A. M.			P. M.			Total for the Day		
	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat
2d.....	9.0	7.	.63	9.7	5.2	.50	18.7	6.04	1.13
3d.....	13.6	5.4	.73	13.7	6.1	.84	27.3	5.75	1.57
4th.....	15.8	5.7	.89	15.0	6.0	.90	30.8	5.81	1.79
5th.....	18.0	6.1	1.10	18.0	5.2	.83	34.0	5.68	1.93
6th.....	19.2	5.3	1.02	18.7	4.9	.81	35.9	5.10	1.83
7th.....	20.5	5.1	1.04	18.6	4.7	.87	39.0	4.90	1.91
8th.....	20.8	4.9	1.02	17.0	4.6	.78	37.8	4.76	1.80
	116.9	5.50	6.43	106.6	5.19	5.53	223.5	5.35	11.96
Butter Equivalent, A. M.			7.50	P. M.			For Week, 13.95		

SECOND WEEK.

Day in Lactation	A. M.			P. M.			Total for the Day		
	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat
9th.....	21.3	4.3	.92	18.0	4.6	.83	39.3	4.45	1.75
10th.....	21.6	4.1	.88	18.0	4.5	.81	39.6	4.27	1.69
11th.....	20.0	4.3	.86	16.2	4.9	.79	36.2	4.56	1.65
12th.....	19.5	4.2	.82	13.8	5.2	.72	33.3	4.62	1.54
13th.....	16.6	4.6	.76	12.0	5.2	.62	28.6	4.83	1.38
14th.....	13.5	5.3	.72	10.5	5.9	.62	24.0	5.58	1.34
15th.....	15.5	5.0	.78	13.5	4.7	.63	29.0	4.86	1.41
	128.0	4.48	5.74	102.0	4.92	5.02	230.0	4.68	10.76
Butter Equivalent, A. M.			6.70	P. M.			For Week, 12.55		

THIRD WEEK.

Day in Lactation	A. M.			D. M.			Total for the Day		
	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat
16th	18.5	4.5	.83	15.7	4.7	.74	34.2	4.59	1.57
17th	19.2	4.6	.88	15.5	5.1	.79	34.7	4.81	1.67
18th	19.0	4.3	.82	15.8	4.7	.74	34.8	4.48	1.56
19th	19.0	4.1	.78	16.8	3.9	.65	35.8	3.99	1.43
20th	19.0	3.6	.68	18.1	4.0	.72	37.1	3.77	1.40
21st	21.5	3.5	.75	19.0	3.8	.72	40.5	3.63	1.47
22d	22.3	3.6	.80	17.5	3.7	.65	39.8	3.64	1.45
	138.5	4.0	5.54	118.4	4.23	5.01	256.9	4.11	10.55
Butter Equivalent, A. M.			6.46	P. M.			5.85		
							For Week, 12.31		

FOURTH WEEK.

Day in Lactation	A. M.			P. M.			Total for the Day		
	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat
23rd	21.0	3.5	.70	18.8	2.9	.55	39.8	3.14	1.25
24th	19.6	3.4	.66	18.0	3.8	.68	37.6	3.56	1.34
25th	20.5	3.5	.72	17.0	3.6	.61	37.5	3.55	1.33
26th	21.0	3.0	.63	18.0	3.6	.65	39.0	3.28	1.28
27th	21.5	3.2	.68	18.4	3.6	.66	39.9	3.36	1.34
28th	21.5	3.1	.66	17.8	3.2	.57	39.3	3.13	1.23
29th	21.8	3.1	.68	18.0	3.7	.67	39.8	3.39	1.35
	146.9	3.22	4.73	126.0	3.48	4.89	272.9	3.34	9.12
Butter Equivalent, A. M.			5.52	P. M.			5.12		
							For Week, 10.64		

The highest test during the first week was 7 per cent., the lowest 4.6, and the average for the week 5.35. The second week the highest test was 5.9; the lowest 4.1, and the average for the week 4.68. The third week the highest test was 5.1, the lowest 3.5; and the average for the week 4.11. The fourth week the highest was 3.8, the lowest 2.9, and the average for the week 3.34. Her average test for the year 1896 was 3.98, and for 1897, 3.71. Her yield of milk and butter fat was during the four weeks as follows:

1st week 223.5 lbs. milk, 11.96 butter fat, 13.95 butter.
 2d week 230.0 lbs. milk, 10.76 butter fat, 12.55 butter.
 3d week 256.9 lbs. milk, 10.55 butter fat, 12.31 butter.
 4th week 272.9 lbs. milk, 9.12 butter fat, 10.64 butter.

As she increased from week to week in the flow of milk, she decreased in the yield of butter fat. She was to all appearances under normal condition, but the test, which is a better indicator of the physical condition than the external appearances, showed otherwise.

To show what changes, if any, take place in the flow of milk and per cent. fat because of change of feed, the following tables are given showing the yield of milk, per cent. fat and total fat from each cow and from the herd during the periods of four weeks before going into pasture, and the first four weeks on pasture; the flow of milk, per cent. fat and total fat for the herd each day, and for each week during the years 1895, 1896, 1897 and 1898.

TABLE OVII.—Yield of Milk and Fat, and Average Per Cent. Fat of Each Cow for Four Weeks Before Going on Pasture and for Four Weeks After.

1895	April 8th to May 5th On Dry Feed			May 6th to June 2d On Pasture		
NAME	Milk Lbs.	Per Cent. Fat	Fat Lbs.	Milk Lbs.	Per Cent. Fat	Fat Lbs.
Allie.....	656.1	3.85	25.26	684.1	3.60	24.61
Beckley 2.....	356.1	5.39	19.21	423.2	5.41	22.88
Belle.....	556.7	3.95	22.00	592.1	4.29	25.38
Bettie.....	321.1	6.26	20.10	366.9	6.17	22.62
Countess.....	1139.4	2.51	28.63	1186.3	2.37	28.09
Ethel.....	725.2	3.76	27.25	762.7	3.79	28.88
Houston.....	681.3	5.06	34.49	742.9	4.85	36.05
Lou.....	743.2	3.63	26.99	948.8	3.37	32.02
Lydia.....	712.8	3.52	25.11	662.6	3.63	24.06
Nora.....	261.6	5.04	13.19	299.2	5.23	15.64
Olive.....	665.6	4.00	26.64	639.6	3.96	25.32
Pride.....	304.6	4.54	13.82	323.3	4.73	15.28
Quidee.....	692.4	3.37	23.35	806.2	3.36	25.83
Reddy.....	398.9	5.24	20.89	440.6	5.34	23.83
Sweet Briar.....	727.0	4.85	35.24	801.2	4.86	38.91
Topsey.....	1064.6	3.69	39.29	1246.5	3.62	45.09
Tricksey.....	449.1	5.18	23.26	518.0	5.08	26.31
Total.....	10855.7	4.06	420.72	11442.1	4.02	460.50
Increase in yield.....	1086.4			39.78		
Average per cow.....	63.90			2.34		
" weekly per cow.....	15.97			.585		
" daily per cow.....	2.28			.083		
Per cent. increase.....	10.49			9.46		

TABLE CVIII.—Daily Yield of Milk and Fat and Per Cent. Fat of Herd Before Going on Pasture and After.

On Dry Feed				On Pasture			
1895	Milk Lbs.	Per Cent Fat	Fat Lbs.	1895	Milk Lbs.	Per Cent Fat	Fat Lbs.
April 8.....	363.6	4.03	14.64	May 6.....	385.7	4.29	16.56
" 9.....	357.4	4.00	14.31	" 7.....	379.2	4.50	17.07
" 10.....	361.7	4.04	14.63	" 8.....	396.2	4.62	18.29
" 11.....	348.5	4.18	14.55	" 9.....	401.2	4.50	18.07
" 12.....	340.5	4.35	14.82	" 10.....	391.9	4.34	17.01
" 13.....	354.5	4.34	15.38	" 11.....	386.0	4.45	16.28
" 14.....	359.2	3.99	14.34	" 12.....	413.4	4.32	17.85
" 15.....	359.7	4.08	14.68	" 13.....	411.1	4.14	17.01
" 16.....	364.9	4.06	14.82	" 14.....	413.2	4.00	16.53
" 17.....	365.2	4.07	14.87	" 15.....	390.2	3.79	14.82
" 18.....	361.2	4.10	14.81	" 16.....	409.0	4.04	16.52
" 19.....	361.1	4.22	15.06	" 17.....	420.8	4.01	16.86
" 20.....	379.9	3.97	15.08	" 18.....	427.7	3.85	16.48
" 21.....	370.3	3.98	14.76	" 19.....	429.1	3.75	16.10
" 22.....	376.4	3.98	15.01	" 20.....	419.2	3.79	15.90
" 23.....	368.8	4.00	14.76	" 21.....	417.2	3.83	15.97
" 24.....	377.5	4.07	15.37	" 22.....	431.4	3.87	16.68
" 25.....	372.4	4.01	14.95	" 23.....	432.3	3.71	16.02
" 26.....	373.3	3.95	14.76	" 24.....	429.0	3.65	15.66
" 27.....	368.8	3.99	14.71	" 25.....	428.8	3.66	15.69
" 28.....	374.0	4.13	15.46	" 26.....	422.4	3.84	16.22
" 29.....	376.1	4.01	15.07	" 27.....	429.5	3.83	16.47
" 30.....	389.7	3.93	15.32	" 28.....	414.5	3.70	15.34
May 1.....	387.7	4.06	15.77	" 29.....	402.6	3.90	15.71
" 2.....	388.6	3.88	15.07	" 30.....	382.7	4.12	15.77
" 3.....	385.8	4.04	15.60	" 31.....	395.5	4.30	17.01
" 4.....	388.3	4.09	15.90	June 1.....	394.7	4.18	16.50
" 5.....	380.4	4.26	16.22	" 2.....	407.6	3.95	16.11
Total.....	10355.7	4.06	420.72	Total.....	11442.1	4.02	460.50

Weekly Variation.

On Dry Feed				On Pasture			
1895	Milk Lbs.	PerCent. Fat	Fat Lbs.	1895	Milk Lbs.	PerCent. Fat	Fat Lbs.
April 8-14.....	2485.4	4.13	102.67	May 6-12.....	2783.6	4.43	121.13
" 15-21.....	2562.3	4.06	104.08	" 13-19.....	2901.1	3.94	114.32
" 22-28.....	2611.2	4.02	105.02	" 20-26.....	2980.3	3.76	112.14
" 29-May 5	2696.8	4.04	108.95	" 27-June 2	2827.1	3.99	112.91
Total.....	10355.7	4.06	420.72	Total.....	11442.1	4.02	460.50

TABLE CIX.—Yield of Milk and Fat and Average Per Cent. Fat of Each Cow for Four Weeks Before Going on Pasture and for Four Weeks After.

1896	April 6th to May 3d On Dry Feed			May 4th to May 31st On Pasture		
NAME	Milk Lbs.	Per Cent. Fat	Total Fat	Milk Lbs.	Per Cent. Fat	Total Fat
Belle.....	586.5	4.20	24.61	678.1	3.98	26.97
Duchess.....	477.5	5.81	27.09	518.1	5.36	27.75
Ethel.....	379.9	4.34	16.48	354.5	3.98	13.94
Fairy.....	328.4	4.72	15.27	335.2	4.68	15.69
Fortune.....	895.6	4.96	44.43	820.8	4.81	39.45
Hope.....	594.1	4.21	25.02	595.2	4.01	23.84
Houston.....	806.0	5.41	43.63	744.9	4.08	30.28
Ida.....	542.5	4.10	22.26	592.4	3.76	22.29
Liggetta.....	490.1	3.98	19.52	561.9	3.72	20.91
Lydia.....	800.0	3.63	29.20	875.0	3.61	31.69
Olive.....	579.8	4.27	24.78	625.2	4.08	25.51
Pride S.....	373.8	4.94	18.46	409.7	4.72	19.34
Quidce.....	608.1	3.70	22.47	610.4	3.52	21.13
Reddy.....	421.8	6.36	26.82	481.5	5.61	26.99
Shortie.....	318.9	5.05	16.09	400.1	4.61	18.43
Sweet Briar.....	504.9	5.16	26.06	402.3	4.83	19.42
Topsy.....	1079.2	3.85	41.58	941.2	3.94	37.07
Tricksey.....	555.7	5.57	30.94	600.6	5.19	31.89
Total.....	10837.8	4.58	473.70	10526.6	4.37	460.49
Increase in yield of milk.....				188.8		
Average increase per cow in yield of milk.....				10.48		
Average weekly increase per cow in yield of milk.....				2.62		
Average daily increase per cow in yield of milk.....				.374		
Decrease in yield of fat.....						13.21
Average decrease per cow in yield of fat.....						.742
Average weekly decrease per cow in yield of fat.....						.186
Average daily decrease per cow in yield of fat.....						.0265
Per cent. increase.....				1.83		
Per cent. decrease.....						2.79

TABLE CX.—Daily Variation in Milk Flow, Per Cent. Fat and Total Fat of the Herd, the Cows Being Turned Onto Pasture May 4th.

On Dry Feed.				On Pasture			
1896	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1896	Milk Lbs.	Per Cent. Fat	Fat Lbs.
April 6...	381.4	4.64	17.70	May 4...	357.3	4.65	16.62
" 7...	385.4	4.71	18.17	" 5...	367.3	4.77	17.52
" 8...	382.8	4.75	18.19	" 6...	380.8	4.50	17.15
" 9...	383.6	4.75	18.24	" 7...	378.6	4.74	17.95
" 10...	379.5	4.80	18.21	" 8...	393.7	4.60	18.13
" 11...	373.4	4.61	17.21	" 9...	389.8	4.70	18.33
" 12...	368.5	4.64	17.10	" 10...	376.5	4.33	16.32
" 13...	374.0	4.51	16.87	" 11...	388.0	4.41	17.13
" 14...	366.6	4.55	16.68	" 12...	386.5	4.19	16.21
" 15...	368.3	4.62	17.03	" 13...	372.0	4.35	16.18
" 16...	356.7	4.60	16.41	" 14...	386.9	4.58	17.74
" 17...	364.2	4.66	16.99	" 15...	360.4	4.53	16.33
" 18...	360.5	4.55	16.40	" 16...	381.8	4.36	16.66
" 19...	360.0	4.43	15.96	" 17...	386.5	4.36	16.85
" 20...	366.1	4.55	16.67	" 18...	378.4	4.20	15.88
" 21...	362.4	4.54	16.46	" 19...	391.3	4.30	16.83
" 22...	365.6	4.51	16.48	" 20...	391.3	4.09	16.02
" 23...	368.8	4.58	16.91	" 21...	387.9	4.05	15.72
" 24...	372.6	4.48	16.70	" 22...	390.5	4.12	16.10
" 25...	368.0	4.55	16.76	" 23...	380.1	4.09	15.56
" 26...	369.9	4.51	16.69	" 24...	376.9	4.20	14.76
" 27...	374.2	4.49	16.80	" 25...	367.6	4.21	15.48
" 28...	370.8	4.50	16.68	" 26...	364.7	4.44	16.18
" 29...	365.3	4.65	16.99	" 27...	373.1	4.29	16.02
" 30...	363.4	4.62	16.78	" 28...	372.6	4.42	16.46
May 1...	366.2	4.54	16.63	" 29...	355.3	4.25	15.11
" 2...	363.9	4.44	16.16	" 30...	362.9	4.44	16.13
" 3...	355.7	4.45	15.83	" 31...	347.9	4.35	15.12
Total.....	10337.8	4.58	473.70	Total.....	10526.6	4.37	460.49

Weekly Variation.

On Dry Feed				On Pasture			
1896	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1896	Milk Lbs.	Per Cent. Fat	Fat Lbs.
April 6-12..	2654.6	4.70	124.82	May 4-10...	2644.0	4.61	122.02
" 13-19..	2550.3	4.56	116.84	" 11-17...	2662.1	4.40	117.10
" 20-26..	2573.4	4.53	116.67	" 18-24...	2696.4	4.11	110.87
" May 3..	2559.5	4.53	115.87	" 25-31...	2544.1	4.34	110.50
Total.....	10337.8	4.58	473.70	Total.....	10546.6	4.37	460.49

TABLE CXI.—Yield of Milk and Fat and Average Per Cent. Fat of Each Cow for Four Weeks Before Going on Pasture and for Four Weeks After.

1897	March 29th to April 25th On Dry Feed			April 26th to May 23d On Pasture		
NAME	Milk Lbs.	Per Cent. Fat	Fat Lbs.	Milk Lbs.	Per Cent. Fat	Fat Lbs.
Countess.....	1010.8	2.80	28.35	1016.8	2.80	28.50
Duchess.....	488.6	6.34	30.96	526.3	6.23	32.81
Fairy.....	1010.8	3.44	34.78	971.6	3.60	34.93
Fly T.....	558.4	4.06	22.66	659.7	3.70	24.42
Liggetta.....	662.6	3.92	25.99	617.6	3.97	24.54
Lil.....	483.1	5.28	25.50	603.2	5.16	30.40
Shortie.....	443.4	4.92	21.80	461.2	4.77	21.98
Sweet Briar.....	617.7	5.61	34.67	761.5	5.31	40.57
Total.....	5275.4	4.26	224.71	5620.9	4.24	238.15
Increase in yield.....				355.5		13.44
Average increase in yield per cow.....				44.43		1.68
Average weekly increase in yield per cow.....				11.11		.42
Average daily increase in yield per cow.....				1.58		.06
Per cent. increase.....				6.74		5.98

TABLE CXII.—Daily Variation in Milk Flow, Per Cent. Fat, and Total Fat for the Herd, the Cows Being Turned into Pasture April 26th.

On Dry Feed				On Pasture			
1897	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1897	Milk Lbs.	Per Cent. Fat	Fat Lbs.
March 29...	192.7	4.22	8.14	April 26.....	188.4	4.14	7.80
" 30...	202.0	4.28	8.64	" 27.....	191.1	4.36	8.37
" 31...	198.4	4.25	8.44	" 28.....	186.8	4.58	8.56
April 1...	198.3	4.19	8.30	" 29.....	190.5	4.50	8.58
" 2...	193.7	4.35	8.43	" 30.....	188.6	4.36	8.23
" 3...	193.9	4.21	8.16	May 1.....	195.5	4.24	8.29
" 4...	192.5	4.33	8.33	" 2.....	191.2	4.53	8.67
" 5...	192.7	4.19	8.08	" 3.....	198.7	4.37	8.68
" 6...	190.2	4.31	8.19	" 4.....	196.6	4.22	8.30
" 7...	188.4	4.25	8.00	" 5.....	198.9	4.22	8.38
" 8...	189.0	4.24	8.02	" 6.....	201.0	4.02	8.08
" 9...	189.0	4.41	8.33	" 7.....	200.8	4.28	8.59
" 10...	188.8	4.31	8.16	" 8.....	203.5	4.11	8.37
" 11...	184.0	4.13	7.59	" 9.....	199.6	4.27	8.53
" 12...	186.7	4.35	8.13	" 10.....	203.7	4.39	8.94
" 13...	179.3	4.52	8.11	" 11.....	197.0	4.18	8.24
" 14...	179.1	4.43	7.93	" 12.....	203.5	4.26	8.66
" 15...	176.8	4.46	7.89	" 13.....	204.8	4.21	8.63
" 16...	187.1	4.13	7.72	" 14.....	207.1	4.14	8.57
" 17...	183.6	4.12	7.56	" 15.....	209.4	4.32	9.05
" 18...	185.0	4.10	7.58	" 16.....	209.4	4.35	9.11
" 19...	183.5	4.37	8.02	" 17.....	204.7	4.20	8.54
" 20...	180.6	4.21	7.61	" 18.....	206.2	4.18	8.61
" 21...	179.8	4.21	7.57	" 19.....	209.4	4.00	8.36
" 22...	187.6	4.23	7.96	" 20.....	215.0	4.00	8.60
" 23...	187.9	4.17	7.83	" 21.....	209.9	4.15	8.71
" 24...	193.6	4.11	7.95	" 22.....	206.2	4.02	8.28
" 25...	191.2	4.21	8.04	" 23.....	203.4	4.12	8.38
Total.....	5275.4	4.26	224.71	Total.....	5620.9	4.24	238.15

Weekly Variation.

On Dry Feed				On Pasture.			
1897	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1897	Milk Lbs.	Per Cent. Fat	Fat Lbs.
Mar. 29-Apr. 4..	1371.5	4.26	58.44	April 26-May 2	1332.1	4.39	58.50
April 5-11.....	1322.1	4.26	56.37	May 3-9.....	1399.1	4.21	58.93
" 12-18.....	1277.6	4.30	54.92	" 10-16.....	1434.9	4.27	61.20
" 19-25.....	1304.2	4.22	54.98	" 17-23.....	1454.8	4.09	59.52
Total.....	5275.4	4.26	224.71	Total.....	5620.9	4.24	238.15

TABLE CXIII.—Yield of Milk and Fat and Average Per Cent. Fat of Each Cow for Four Weeks Before Going on Pasture and for Four Weeks After.

1898	April 4th to May 1st On Dry Feed			May 2d to 29th On Pasture		
	Milk Lbs.	Per Cent. Fat	Total Fat	Milk Lbs.	Per Cent. Fat	Total Fat
Alzanka.....	280.9	5.45	15.30	324.5	5.33	17.30
Alzanka 2.....	466.6	4.99	23.26	521.0	5.14	26.76
Bess 2.....	664.6	3.83	25.46	822.8	3.65	30.07
Bettie C.....	573.7	4.33	24.81	677.0	4.49	30.41
Countess.....	947.7	2.95	27.91	953.4	2.93	27.89
Countess 2.....	621.3	3.19	19.84	781.6	3.05	23.86
Daisy.....	457.7	4.77	21.84	567.7	4.69	26.15
Flairy B.....	447.8	4.81	21.53	532.3	4.96	26.42
Flora.....	377.5	5.08	19.19	473.9	5.13	24.29
Fly T.....	682.8	3.87	26.44	807.2	3.89	31.34
Golden Fairy.....	431.5	4.66	20.09	431.7	4.81	20.78
Houston.....	173.3	5.54	9.60	216.0	5.55	11.96
Jet.....	295.6	4.86	14.42	277.9	5.15	14.31
Lou 2.....	367.4	3.85	14.27	509.8	3.72	18.98
Nora.....	421.8	4.75	20.04	530.3	4.72	25.03
Pride 2.....	397.5	4.74	18.87	477.0	4.83	23.03
Spot.....	357.0	4.77	17.04	417.8	4.94	20.62
Sweet Briar.....	251.7	5.18	14.00	241.0	5.42	13.06
Topsy 3.....	343.9	4.56	15.72	352.9	4.83	17.06
Yellow Belle.....	408.7	4.65	19.03	460.4	4.75	21.89
Young Daisy.....	254.0	5.77	14.64	274.8	5.81	15.97
Total.....	9223.0	4.37	403.30	10641.0	4.39	467.24
Increase in yield.....				1418.0		63.94
Average increase per cow.....				67.52		3.04
Average weekly increase per cow.....				16.88		.76
Average daily increase per cow.....				2.41		.108
Per cent. increase.....				15.37		15.85

TABLE CXIV.—Daily Variation in Milk Flow, Per Cent. Fat and Total Fat for the Herd, the Cows Being Turned onto Pasture May 2d.

On Dry Feed				On Pasture			
1898	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1898	Milk Lbs.	Per Cent. Fat	Fat Lbs.
April 4.....	328.3	4.66	15.30	May 2.....	324.7	4.24	13.77
" 5.....	331.3	4.68	15.49	" 3.....	330.0	4.53	14.94
" 6.....	343.9	4.30	14.78	" 4.....	346.5	4.66	16.15
" 7.....	336.8	4.44	14.94	" 5.....	348.2	4.69	16.34
" 8.....	333.3	4.38	14.59	" 6.....	350.1	4.50	15.77
" 9.....	325.5	4.89	14.28	" 7.....	360.7	4.06	14.63
" 10.....	323.2	4.43	14.31	" 8.....	368.3	4.38	16.13
" 11.....	328.5	4.43	14.56	" 9.....	380.7	4.44	16.90
" 12.....	330.3	4.20	13.88	" 10.....	393.4	4.41	17.33
" 13.....	331.3	4.34	14.38	" 11.....	389.6	4.55	17.73
" 14.....	338.7	4.35	14.72	" 12.....	385.3	4.48	17.28
" 15.....	346.5	4.30	14.89	" 13.....	365.0	4.41	16.11
" 16.....	338.9	4.45	15.10	" 14.....	377.9	4.33	16.36
" 17.....	340.7	4.45	15.16	" 15.....	376.7	4.32	16.29
" 18.....	342.6	4.29	14.71	" 16.....	371.5	4.45	16.53
" 19.....	318.4	4.64	14.79	" 17.....	356.9	4.45	15.88
" 20.....	322.5	4.49	14.49	" 18.....	359.5	4.40	15.82
" 21.....	330.6	4.88	14.49	" 19.....	354.3	4.40	15.58
" 22.....	322.7	4.29	13.83	" 20.....	403.1	4.55	18.36
" 23.....	318.2	4.34	13.80	" 21.....	415.9	4.40	17.90
" 24.....	331.7	4.47	14.82	" 22.....	418.8	4.33	18.13
" 25.....	320.3	4.47	14.31	" 23.....	416.6	4.37	18.21
" 26.....	333.1	4.25	14.15	" 24.....	418.2	4.30	18.00
" 27.....	328.5	4.24	13.93	" 25.....	410.7	4.28	17.50
" 28.....	321.0	4.19	13.46	" 26.....	405.9	4.17	16.93
" 29.....	321.7	4.20	13.50	" 27.....	410.5	4.18	17.14
" 30.....	319.9	3.98	12.76	" 28.....	399.2	4.42	17.66
May 1.....	314.6	4.41	13.88	" 29.....	402.8	4.44	17.87
Total.....	9223.0	4.37	403.30	Total.....	10641.0	4.39	467.24

Weekly Variation.

On Dry Feed				On Pasture			
1898	Milk Lbs.	Per Cent. Fat	Fat Lbs.	1898	Milk Lbs.	Per Cent. Fat	Fat Lbs.
April 4-10.....	2322.3	4.46	103.69	May 2-8.....	2428.5	4.44	107.73
" 11-17.....	2354.9	4.36	102.69	" 9-15.....	2668.6	4.42	118.00
" 18-24.....	2286.7	4.41	100.93	" 16-22.....	2680.0	4.41	118.20
" 25-May 1.....	2269.1	4.25	95.99	" 23-29.....	2863.9	4.31	123.31
Total.....	9223.0	4.37	403.30	Total.....	10641.0	4.39	467.24

Since it is the practice to feed the cows during the winter some succulent food, such as ensilage or roots, it is not expected that any great change will take place when turned onto pasture. Had the cows been on dry feed only, two or

three months before going to pasture, more definite results might have been obtained. During the latter part of the winter of 1895 and up to the time of going to pasture, which was on May 6th, the cows received a ration composed of 9 pounds of grain, 14 of hay and 9 of roots. The roots were discontinued and the grain and hay gradually reduced, and after the second week they received on an average 2 pounds of grain per day. The average daily increase was, in milk, 2.28 pounds, and butter fat .08 pounds, being an increase in round numbers of 10.5 per cent. in milk and 9.5 in butter fat. The average per cent. fat of the milk of the herd for the period of four weeks before going onto pasture was 4.06 and for the first four weeks on pasture 4.02. The greatest variation in the test of the herd's milk before going onto pasture, for two consecutive days, was 4.35 on the 13th of April and 3.99 on the 14th. During the first 12 days on pasture the test fell below 4 per cent. only once, while during the 12 days following it never tested as high as 4 per cent. The average weekly test of the herd's milk was always above 4 per cent. before going to pasture. While the test for the first week on pasture was 4.4, the second week it was 3.9, being a variation in a week of a half of 1 per cent.

In the spring of 1896 the cows received as a standard ration 8 pounds of hay, 14 of grain and 20 pounds of ensilage. During the first week when on pasture the ensilage and hay were gradually discontinued and the grain was reduced so that the cows received from two to four pounds of grain. The daily increase in yield of milk was only a trifle over one-third of a pound, and the fat decreased .02 of a pound. The average test of the herd during four weeks before going onto pasture was 4.58, while the average test of the herd during the first four weeks on pasture was 4.37. The yield of milk increased during the four weeks 1.83 per cent. and the butter fat decreased 2.79 per cent. The greatest variation on two consecutive days in the per cent. fat of the milk from the herd was 4.80 on the 10th of April and 4.61 on the

11th, and after going to pasture, 4.70 on the 9th of May and 4.33 on the 10th. The greatest weekly variation was when the average test for the herd for the week ending May 24th was 4.11 and for the week ending May 31st, 4.34.

In the spring of 1897 when the cows were fed in the barn they received a ration composed of 11 pounds of grain and 33 pounds of ensilage. They were turned into pasture April 26th and the ensilage gradually withdrawn the first week and the grain ration reduced to from 2 to 4 pounds each. During the first four weeks that the herd was in pasture the average daily gain in the flow of milk was 1.58 pounds per cow and the average daily gain in butter fat was .06 of a pound or practically a half a pound of butter per week. The daily increase in milk 6.74 per cent. and of butter fat 5.98 per cent. The greatest variation in the quality of milk was that from the Guernsey Sweet Briar, whose milk tested on an average 5.61 before going onto pasture and 5.31 during the first four weeks on pasture. The average test of the herd during the four weeks before going to pasture was 4.26, and the first four weeks on pasture 4.24. The greatest variation in the per cent. fat in the milk from the herd before going to pasture was when it tested 4.46 on the 15th of April and 4.13 on the 16th. The first day the herd was on pasture the milk tested 4.14 and the second day it tested 4.38. The milk from the herd during the first week in pasture tested 4.39 and the second week it tested 4.21, or a difference of practically two points in two consecutive weeks.

During the spring of 1898 before going to pasture the cows were fed a ration composed of two parts each of grain and roots and three parts of hay. They were turned on a blue grass pasture that was making rapid growth, the 2d day of May. Their daily average increase in the flow of milk was 2.41 pounds and their daily average gain in butter fat was .1 pound. The increase in milk was 15.37 per cent. and of butter fat 15.85 per cent. The average test

of the herd during the last four weeks on stall feed was 4.37 and the first four weeks on pasture 4.39. The greatest variation in the fat content of milk was Jet's that tested 4.86 before going to pasture and 5.15 on pasture. The greatest variation in the test of milk from the herd was 3.98 April 30th and 4.41 May 1st. On the 6th of May when on pasture the milk tested 4.50 and on the 7th it tested 4.06.

In the foregoing tables comparison was made with reference to variation in flow of milk, yield of butter fat and per cent. fat content, during a period of four weeks before going to pasture and a period of the first four weeks on pasture. In examining the records in detail it was found that cows, as a general rule, during the last week that they are on dry feed give milk containing less per cent. of fat than that yielded one or two weeks immediately preceding it, and that during the first week on pasture it contains a greater per cent. fat than it does the last week on dry feed, indicating that these variations are due to other influences. The decrease in the quality of the milk during the week immediately preceding the first week on pasture is probably due to discontent because of a desire to go to pasture, and the increase in the per cent. of fat during the first week is probably due to excessive exercise in roaming over the pasture. To show more in detail the variation in yield and quality of milk when on stall feed and when in pasture, tables are submitted showing the yield of milk and butter fat and the per cent. fat contained in the milk for four periods of two weeks each before cows were turned on pasture and for four periods after. The tables show the influence of feed on the yield of milk and butter from each cow and on the herd during a period of four years.

TABLE OXV.—Giving Yield of Milk for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1895	On Dry Feed				On Pasture			
Belle.....	276.3	264.8	257.4	299.3	307.3	282.2	307.9	273.4
Countess.....	609.7	571.9	561.4	578.0	578.9	607.4	596.8	532.4
Ethel.....	396.2	385.4	364.2	361.0	383.9	378.8	364.8	348.5
Houston.....	355.9	344.5	339.3	342.0	367.2	393.6	308.8	307.3
Low.....	470.1	433.7	356.9	386.3	454.5	494.3	473.3	443.8
Lydia.....	858.8	866.5	328.9	330.0	354.3	355.5	330.9	278.4
Olive.....	306.9	278.1	277.8	287.8	324.5	315.1	296.1	271.8
Pride.....	153.8	143.6	148.9	155.7	162.0	162.2	159.2	144.6
Quidee.....	374.7	356.4	336.3	356.1	388.3	416.9	392.2	357.9
Sweet Briar.....	361.2	362.4	356.7	370.3	390.6	411.3	401.3	367.8
Topsy.....	560.5	532.3	508.6	555.5	609.3	636.2	602.1	571.8
Total.....	4224.1	4039.6	3836.4	4022.0	4320.8	4453.5	4233.4	3897.7

TABLE OXVI.—Giving Yield of Milk for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1896	On Dry Feed				On Pasture			
Belle.....	297.5	284.2	293.2	284.3	341.8	336.3	289.0	266.8
Duchess.....	239.7	240.9	243.6	233.9	260.6	257.5	223.9	215.5
Ethel.....	237.9	222.2	191.3	188.6	178.5	176.0	161.6	146.7
Fairy.....	159.6	156.5	166.9	154.1	179.1	178.4	218.3	243.2
Fortune.....	473.5	470.0	462.7	432.9	416.1	404.2	382.0	406.4
Houston.....	417.6	417.4	410.6	395.4	375.0	369.9	375.1	371.5
Ida.....	280.3	282.9	265.5	277.0	296.5	294.9	286.8	296.4
Lydia.....	417.9	414.1	405.7	394.3	436.5	438.5	411.4	380.5
Olive.....	288.0	291.9	282.4	297.4	320.6	304.6	272.4	261.3
Shortie.....	145.5	153.6	153.0	165.9	199.3	200.8	209.5	187.7
Sweet Briar.....	324.8	312.9	271.3	233.6	217.2	185.1	170.9	180.2
Topsy.....	584.1	571.6	563.1	516.1	486.8	454.4	426.1	425.9
Total.....	3866.4	3818.2	3709.3	3573.5	3708.0	3600.6	3427.0	3382.1

TABLE OXVII.—Giving Yield of Milk for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1897	On Dry Feed				On Pasture			
Countess.....	546.4	536.8	518.8	592.0	511.6	505.0	486.1	466.7
Duchess.....	251.1	245.9	245.0	243.6	236.0	291.3	269.6	272.1
Fly T.....	274.7	265.9	279.2	279.2	316.3	343.4	321.6	285.7
Liggetta.....	342.6	323.2	325.4	337.2	314.8	302.8	253.9	208.1
Lil.....	265.6	244.6	256.3	226.8	271.6	331.6	319.8	300.8
Shortie.....	240.3	227.1	232.1	210.4	232.5	228.7	211.5	195.1
Sweet Briar.....	313.5	296.0	300.2	317.1	358.6	405.9	360.8	332.1
Total.....	2234.2	2139.5	2157.0	2206.3	2241.4	2408.7	2223.3	2060.6

TABLE CXVIII.—Giving Yield of Milk for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1898	On Dry Feed				On Pasture			
Alzanka.....	128.5	144.1	187.9	143.0	156.6	167.9	172.7	.....
Alzanka 2.....	250.7	249.5	236.6	280.0	259.3	281.7	270.0	225.4
Bess.....	276.8	285.6	324.7	339.9	400.1	422.7	415.7	370.9
Betty 2.....	298.8	294.5	291.0	282.7	324.8	352.2	375.5	342.2
Countess.....	578.6	538.0	491.6	456.1	440.2	513.2	494.9	414.9
Countess 2.....	387.3	288.5	310.8	310.5	364.9	416.7	413.5	370.8
Daisy.....	268.4	229.1	229.1	228.6	273.9	288.8	284.1	252.4
Fairy B.....	214.5	225.5	222.0	225.8	264.1	268.2	266.6	211.2
Flora.....	189.4	200.0	194.3	183.2	219.0	254.9	226.7	186.5
Fly T.....	329.7	344.1	344.3	338.5	388.2	419.0	408.0	338.2
Fortune 2.....	174.7	179.1	173.3	173.9	193.1	209.6	268.0	261.9
Golden Fairy.....	250.5	234.1	228.9	207.6	191.0	240.7	257.8	224.0
Nora.....	237.7	237.1	230.2	191.6	254.0	276.3	283.0	252.0
Pride.....	204.8	196.3	196.3	201.2	232.2	244.8	246.9	206.5
Spot.....	172.9	187.9	178.1	178.9	206.1	211.7	214.4	183.8
Yellow Belle.....	224.6	216.9	211.6	197.1	224.2	236.2	247.6	213.1
Young Daisy.....	130.3	144.2	132.4	121.6	129.9	144.9	144.9	130.3
Total.....	4267.2	4194.5	4128.1	4010.2	4521.6	4924.5	4990.3	4184.1
Without Alzanka	4138.7	4050.4	3990.2	3867.2	4365.0	4756.6	4817.6	4184.1

TABLE CXIX.—Yield of Milk for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

YEAR	On Dry Feed				On Pasture			
1895.....	4224.1	4039.6	3836.4	4022.0	4320.8	4453.5	4233.4	3897.7
1896.....	3866.4	3818.2	3709.3	3573.5	3708.0	3600.6	3427.0	3352.1
1897.....	2234.2	2139.5	2157.0	2206.3	2241.4	2408.7	2223.3	2060.5
1898.....	4138.7	4050.4	3990.2	3867.2	4365.0	4756.6	4817.6	4184.1
Total.....	14463.4	14047.7	13692.9	13669.0	14635.2	15219.4	14710.3	13524.5

TABLE CXX.—Giving Yield of Butter Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1895	On Dry Feed				On Pasture			
Belle.....	11.67	11.26	10.61	11.39	13.04	12.31	12.87	11.59
Countess.....	14.41	15.14	14.51	14.12	14.67	13.42	13.79	12.93
Ethel.....	17.17	16.05	14.12	13.13	14.90	13.98	13.13	13.16
Houston.....	19.36	17.82	17.24	17.25	18.77	17.28	14.52	16.90
Lou.....	16.84	16.04	13.00	13.99	15.93	16.09	15.99	15.34
Lydia.....	12.30	12.57	12.36	11.47	13.37	12.40	12.50	10.90
Olive.....	12.64	11.79	10.98	11.66	13.32	11.93	10.96	11.56
Pride.....	8.00	6.91	6.90	6.97	8.18	7.10	6.86	6.27
Quidee.....	13.45	12.79	11.25	12.10	12.96	12.87	11.67	11.37
Sweet Briar.....	19.18	18.64	17.48	17.76	20.26	18.63	17.95	18.11
Topsy.....	21.58	20.40	18.94	20.85	22.64	22.45	23.89	22.62
Total.....	166.60	159.41	147.39	150.69	168.04	158.46	154.13	150.75

TABLE CXXI.—Giving Yield of Butter Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1896	On Dry Feed				On Pasture			
Belle.....	11.35	11.68	12.29	12.32	14.06	12.91	11.45	10.81
Duchess.....	12.73	13.39	14.06	13.03	14.28	13.47	11.78	11.26
Ethel.....	9.64	8.94	8.60	7.88	7.00	6.94	6.16	5.46
Fairy.....	6.96	7.66	7.71	7.26	8.43	7.75	9.08	9.06
Fortune.....	21.09	20.63	22.58	21.85	20.31	19.14	17.51	17.39
Houston.....	20.13	21.33	22.44	21.19	19.86	18.43	17.34	17.54
Ida.....	10.79	10.67	11.38	10.88	11.68	10.61	10.51	10.67
Lydia.....	13.75	13.83	14.69	12.59	16.33	15.26	14.52	13.83
Olive.....	11.62	11.70	12.27	12.51	13.41	12.10	10.99	10.82
Shortie.....	7.44	7.44	7.92	8.17	9.58	8.55	9.71	8.95
Sweet Briar.....	16.05	15.25	14.13	11.93	10.86	8.56	8.04	8.82
Topsy.....	20.81	19.13	21.66	19.92	19.71	17.36	16.64	15.91
Total.....	162.86	161.65	169.73	159.53	165.50	151.38	142.73	140.50

TABLE CXXII.—Giving Yield of Butter Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1897	On Dry Feed				On Pasture			
Countess.....	15.40	15.29	14.78	13.57	14.39	14.11	12.82	13.03
Duchess.....	15.22	15.43	15.51	15.45	16.03	16.78	14.74	14.12
Ply T.....	10.80	10.72	11.13	11.53	12.32	12.10	11.38	10.89
Liggetta.....	13.49	12.44	12.81	13.12	12.70	11.85	9.73	8.03
Lil.....	14.30	13.43	13.81	11.69	13.86	16.54	15.33	15.36
Shortie.....	11.90	11.34	11.70	10.10	11.37	10.57	9.74	9.93
Sweet Briar.....	17.20	17.05	17.16	17.51	19.30	21.27	17.42	16.96
Total.....	98.31	95.70	96.90	92.97	99.97	108.22	91.11	88.32

TABLE CXXIII.—Giving Yield of Butter Fat for Four Periods of Two Weeks Each, Before Cows Went on Pasture and for Four Periods After.

1898	On Dry Feed				On Pasture			
Alzanka.....	6.99	8.08	7.64	7.66	8.68	8.62	7.86	.....
Alzanka 2.....	10.61	12.55	11.98	10.93	13.28	13.53	12.81	11.35
Bess.....	11.69	11.98	12.67	12.79	14.93	15.14	13.65	13.50
Betty 2.....	12.75	12.82	12.80	12.01	14.11	16.30	16.44	14.98
Countess.....	15.29	15.09	14.65	12.33	13.34	14.55	13.18	11.04
Countess 2.....	9.84	10.11	10.13	9.71	11.55	12.31	11.35	9.91
Daisy.....	12.50	11.71	11.08	10.76	13.01	13.14	12.45	11.29
Fairy B.....	9.88	11.00	10.69	10.84	12.91	13.51	12.03	10.04
Flora.....	9.19	10.43	9.91	9.29	11.21	13.08	10.85	9.78
Ply T.....	12.75	13.77	13.42	13.00	15.04	16.34	15.21	12.91
Fortune 2.....	9.30	9.55	9.31	9.17	10.61	11.53	13.78	13.79
Golden Fairy.....	10.12	10.46	10.34	9.75	9.61	11.17	11.68	10.31
Nora.....	10.17	11.12	10.79	9.26	11.94	13.09	12.25	11.43
Pride.....	9.42	9.82	9.55	9.32	11.00	12.03	11.37	9.94
Spot.....	7.81	9.43	8.53	8.51	10.07	10.55	9.55	8.73
Yellow Belle.....	9.14	10.35	10.05	8.98	10.83	11.06	10.87	9.27
Young Daisy.....	7.07	8.15	7.71	6.93	7.74	8.23	7.76	7.42
Total.....	174.52	185.92	181.25	171.24	199.81	214.18	208.09	175.69
Without Alzanka.....	167.53	177.84	173.61	163.58	191.13	205.56	195.23	175.69

TABLE CXXIV.—Giving Yield of Butter Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Weeks After.

YEAR	On Dry Feed				On Pasture			
1895.....	166.60	159.41	147.39	150.69	168.04	158.46	154.13	150.75
1896.....	162.36	161.65	169.73	159.53	165.50	151.38	142.73	140.50
1897.....	98.81	95.70	96.90	92.97	99.97	103.22	91.11	88.32
1898.....	167.53	177.84	173.61	163.58	191.13	205.56	195.23	175.69
Total.....	594.80	594.60	587.63	566.77	624.64	618.62	583.20	555.26

TABLE CXXV.—Giving Average Per Cent. Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1895	On Dry Feed				On Pasture			
Belle.....	4.22	4.25	4.12	3.81	4.24	4.36	4.18	4.24
Countess.....	2.36	2.65	2.58	2.44	2.53	2.21	2.31	2.43
Ethel.....	4.33	4.16	3.88	3.64	3.88	3.69	3.60	3.78
Houston.....	5.44	5.17	5.08	5.04	5.11	4.39	4.70	5.50
Lou.....	3.58	3.70	3.64	3.62	3.50	3.26	3.38	3.46
Lydia.....	3.43	3.43	3.76	3.48	3.77	3.49	3.78	3.92
Olive.....	4.12	4.23	3.95	4.05	4.10	3.79	3.70	4.25
Pride.....	5.20	4.81	4.63	4.48	5.05	4.38	4.31	4.34
Quidee.....	3.59	3.59	3.85	3.40	3.34	3.09	2.98	3.18
Sweet Briar.....	5.31	5.14	4.90	4.80	5.19	4.53	4.47	4.92
Topsy.....	3.85	3.83	3.72	3.75	3.72	3.53	3.97	3.96
Average.....	3.95	3.95	3.84	3.75	3.89	3.56	3.64	3.87

TABLE CXXVI.—Giving Average Per Cent. Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1896	On Dry Feed				On Pasture			
Belle.....	3.82	4.11	4.19	4.33	4.11	3.84	3.96	4.05
Duchess.....	5.31	5.56	5.77	5.57	5.48	5.23	5.26	5.23
Ethel.....	4.05	4.02	4.50	4.18	3.92	3.94	3.81	3.72
Fairy.....	4.36	4.89	4.62	4.71	4.71	4.34	4.16	3.72
Fortune.....	4.45	4.39	4.88	5.06	4.88	4.74	4.58	4.28
Houston.....	4.82	5.11	5.47	5.36	5.29	4.98	4.62	4.72
Ida.....	3.85	3.77	4.29	3.93	3.94	3.60	3.66	3.60
Lydia.....	3.29	3.34	3.62	3.19	3.74	3.48	3.53	3.63
Olive.....	4.03	4.01	4.34	4.21	4.18	3.97	4.03	4.14
Shortle.....	5.11	4.84	5.18	4.92	4.81	4.41	4.63	4.77
Sweet Briar.....	4.84	4.87	5.21	5.11	5.00	4.62	4.71	4.89
Topsy.....	3.56	3.35	3.85	3.86	4.05	3.82	3.67	3.74
Average.....	4.20	4.23	4.58	4.46	4.46	4.20	4.16	4.15

TABLE CXXVII.—Giving Average Per Cent. Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1897	On Dry Feed				On Pasture			
Countess	2.82	2.85	2.85	2.29	2.81	2.79	2.64	2.79
Duchess.....	6.06	6.27	6.33	6.34	6.79	5.76	5.47	5.19
Fly T.....	3.93	4.03	3.99	4.13	3.90	3.52	3.52	3.81
Liggetta.....	3.94	3.85	3.94	3.89	4.03	3.91	3.83	3.86
Lil.....	5.88	5.49	5.39	5.15	5.10	4.99	4.79	5.11
Shortie.....	4.95	4.99	5.04	4.80	4.89	4.82	4.61	5.09
Sweet Briar.....	5.49	5.76	5.72	5.41	5.38	5.24	4.88	5.11
Average.....	4.40	4.47	4.49	4.21	4.46	4.39	4.10	4.29

TABLE CXXVIII.—Giving Per Cent. Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

1898	On Dry Feed				On Pasture			
Alzanka.....	5.44	5.61	5.54	5.36	5.54	5.13	4.65	5.04
Alzanka 2.....	4.23	5.03	5.06	4.75	5.10	5.17	4.74	5.04
Bess.....	4.23	4.19	3.90	3.76	3.73	3.50	3.28	3.64
Betty 2.....	1.27	4.30	4.40	4.25	4.34	4.63	4.88	4.89
Countess.....	2.64	2.80	2.98	2.70	3.03	2.84	2.66	2.66
Countess 2.....	2.92	3.50	3.26	3.13	2.66	2.95	2.74	2.67
Daisy.....	4.66	5.11	4.84	4.71	4.75	4.63	4.38	4.47
Fairy B.....	4.61	4.88	4.82	4.80	4.89	5.04	4.51	4.75
Flora.....	4.85	5.22	5.10	5.07	5.12	5.13	4.79	5.24
Fly T.....	3.87	4.00	3.90	3.84	3.87	3.90	3.73	3.82
Fortune 2.....	5.32	5.33	5.37	5.27	5.49	5.50	5.14	5.27
Golden Fairy.....	4.04	4.47	4.62	4.70	5.03	4.64	4.53	4.60
Nora.....	4.28	4.69	4.69	4.83	4.70	4.74	4.33	4.54
Pride.....	4.60	4.75	4.87	4.63	4.95	4.91	4.61	4.81
Spot.....	4.52	5.02	4.79	4.76	4.89	4.98	4.45	4.75
Yellow Belle.....	4.07	4.77	4.75	4.56	4.83	4.68	4.39	4.35
Young Daisy.....	5.43	5.65	5.82	5.70	5.96	5.68	5.36	5.69
Average.....	4.09	4.43	4.39	4.27	4.42	4.35	4.07	4.20
Without Alzanka,	4.05	4.39	4.35	4.23	4.38	4.32	4.05	4.20

TABLE CXXIX.—Average Per Cent. Fat for Four Periods of Two Weeks Each Before Cows Went on Pasture and for Four Periods After.

YEAR	On Dry Feed				On Pasture			
1895.....	3.95	3.95	3.84	3.75	3.89	3.56	3.64	3.87
1896.....	4.20	4.23	4.58	4.46	4.46	4.20	4.16	4.15
1897.....	4.40	4.47	4.49	4.21	4.46	4.29	4.10	4.29
1898.....	4.05	4.39	4.35	4.23	4.38	4.32	4.05	4.20
Average.....	4.11	4.23	4.29	4.15	4.27	4.06	3.96	4.11

The tables show that, with a single exception, the herd yielded more milk during the first two weeks on pasture than it did the eighth and seventh weeks, before going to pasture, and that on the average it yielded more milk the fourth period on pasture than it did the last period, when stall fed; that the same is true as regards the yield of butter fat.

The tables giving the per cent. fat content in the milk of different cows and the average for the herd in the four years, during the eight periods of two weeks each, show that the per cent. fat increases as the period of lactation advances until the last period of stall feeding when there is a uniform decrease in the quality of milk; that in every instance the milk of the herd increased during the first period of two weeks on pasture and is followed by a marked decrease in per cent. fat during the second and third periods on pasture, and that during the fourth period on pasture it is the same as it was during the eighth and seventh weeks before going to pasture; indicating that the influence of feed reduced the per cent. of fat in the milk from 4.29 to 3.96.

The following table gives the yield of milk, per cent. fat and yield of butter fat by the herd for each of four years, for a period of four weeks preceding a period of two weeks before going to pasture and for a period of four weeks following a period of two weeks after going to pasture:

VARIATION IN FLOW OF MILK.

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YEAR	ON DRY FEED						ON PASTURE					
	Period of Four Weeks			Period of Two Weeks			Period of Two Weeks			Period of Four Weeks		
	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat	Milk	Per Cent. Fat	Butter Fat
1895.....	7876.0	3.90	306.80	4022.0	3.75	150.69	4320.8	3.89	168.04	8686.9	3.60	312.59
1896.....	7527.5	4.40	331.38	3573.5	4.46	159.53	3708.0	4.46	165.50	7027.6	4.19	294.11
1897.....	4296.5	4.48	192.60	2206.3	4.21	92.97	2241.4	4.46	99.97	4632.0	4.20	194.33
1898.....	8040.6	4.37	351.45	3867.2	4.23	163.58	4365.0	4.38	191.13	9574.2	4.12	400.79
Total.....	27740.6	4.26	1182.23	13669.0	4.15	566.77	14635.2	4.27	654.64	29920.7	4.02	1201.82

Notwithstanding the fact that the cows received corn silage while they were being stall fed, and while on pasture received what grain they wanted, the average test of the herd's milk for the four years during a period of four weeks immediately preceding a period of two weeks before going to pasture was 4.26, while the average test for the same length of time following a period of two weeks on pasture was 4.02. The flow of milk during the four-week period on pasture was 7.85 per cent. greater than during the four-week period on stall feed. The increase in the yield of butter fat was 1.65 per cent. and the per cent. fat decreased 5.63 per cent. The average test of the herd's milk for four years during the first two weeks on pasture was 4.27 and during the four weeks following it averaged 4.02, being a decrease in the per cent. fat of 5.85 per cent. The average test of the herd's milk during the last two weeks on stall feed was 4.15, and during the first two weeks on pasture was 4.27, being an increase of 2.89 per cent.

FEEDING DAIRY COWS.

T. L. HÆCKER.

The question of feeding dairy stock in such a way that farmers can realize the greatest possible benefit from the food consumed and animals employed is one of vital importance in these times when the margin between the price of the product and the cost of production has become so small that it is only by reducing the cost of food to the minimum that reasonable profits can be made. In order to feed economically, the animal must be supplied with the nutrients needed for milk production in the proper quantity and in the right proportion. If an animal is given more of a certain nutrient than it can make use of, the excess is worse than wasted, because it not only helps to fill the digestive tract with that for which it has no use, but energy is also wasted in expelling it from the system.

The real feeding value of our different kinds of foods is as yet little understood. In the mean time, until further investigation enables us to classify foods according to their feeding value, they have been compared according to their *money* value, digestible protein having, for reasons given later, been used as a basis for comparison. The market prices for the different kinds of coarse fodder, grains and mill products are based upon supply and demand, and not so much upon their feeding value. Farmers as a general rule know that bran is good for dairy cows. They also know that corn, oats and barley are good, but they do not seem to understand why a mixture of such excellent foods as corn, oats, and barley will not produce as good results as can be secured by feeding

bran and other concentrated meals in connection with them. The reason is plain when the needs of the animal system and the composition of the different kinds of foods are known. All animal foods are divided into two classes with reference to bulk: Roughage and concentrates. Roughage includes all the coarse portions of the ration, such as hay, stover, fodder corn, silage, roots, etc., while the term "concentrates" embraces all grains and mill products.

It has become necessary to feed concentrates in connection with roughage because the dairy cow has been developed into an artificial animal. Had she remained in her original state, when she yielded only enough milk to nourish her young, she would find enough nutriment in what coarse feed she could eat and digest to produce the amount of milk required for that purpose, but since her mammary functions have been developed more than her feeding capacity, we must establish an equilibrium between the supply and demand for nutriment needed for the production of the milk, and to this end we must use some food that contains a larger percentage of digestible matter than is found in coarse food.

In feed there are three groups of substances which must be considered in formulating a ration to secure best results. These are known as protein, carbohydrates, and fat.

Protein is the name of a group of materials containing nitrogen, and is sometimes called the nitrogenous group, in opposition to the carbohydrates, fat and ash, which are non-nitrogenous. The function of protein is to furnish materials for the formation of lean flesh, blood, tendons, nerves, hair, horns, wool, and of the casein and albumin of milk. For the formation of these materials protein is absolutely indispensable. It is important to remember that no substance free from nitrogen can be converted into protein, or be used as a substitute for it. It is therefore necessary for an animal to receive a certain amount of protein in order to maintain existence, grow or produce milk.

Carbohydrates are made up of several substances, usually divided into two groups,—nitrogen free extract, including starch, sugar, gums, etc., and crude fiber. Coarse fodders contain large amounts of crude fiber, while grain and mill stuffs contain little fiber, but are rich in starch and sugar. Carbohydrates are either converted into fat or burned in the system to produce heat and energy.

Fat, or the material dissolved from a feeding stuff by ether, and for this reason often designated as ether extract, includes the fat, wax, and green coloring matter of plants. The fat of food is stored up in the body as fat, used as a lubricator for the digestive tract, and burned to furnish heat and energy. As a heat producer a pound of fat is equivalent to 2.5 pounds of carbohydrates. When fat has been multiplied by this factor, the result is called "carbohydrate equivalent."

A cow, or in fact nearly any mature animal, can use only about 6 pounds of digestible carbohydrates and carbohydrate equivalent to one of protein. If we feed more carbohydrates without increasing the protein, there will be an abnormal shrinkage in the flow of milk, because the increase will cause the animal to lay on fat. If the ratio of protein to carbohydrates and carbohydrate equivalent is narrowed, the animal may need more heat than the carbohydrates and fat can supply, and in such case would consume some of the more expensive protein to make up the deficiency. It follows, therefore, that for the best results the two groups of nutrients, protein and carbohydrates, should be fed within the limits stated.

But all our ordinary feeds, both in grain and roughage, contain carbohydrates largely in excess of the animal's needs, and, mix the grain and roughage grown on the farm as we will, it always follows that we are short in protein or have too much of carbohydrates. In fact, all the nutrients needed by our farm animals are found in all our farm food in great abundance except protein. In marsh and

prairie hay, in timothy, millet, sorghum, fodder corn, stover, and straw, there is more digestible carbohydrates and ether extract than cattle can make use of. The same is true with all our farm grown grains. In compounding rations with our farm crops, we always find it necessary to resort to mill products containing a low percentage of carbohydrates, to rid them from excess of carbohydrates, except in cases where such foods as alfalfa are available.

Since the supply of ash, carbohydrates, and fat is always in excess of our needs, and is practically as free as water, air and light, it follows that they lose all commercial value, leaving digestible protein the measure of the money value of all our feed stuffs for milk production.

A ton of bran costs \$10. It contains 230 pounds of water. It would be foolish to place any value on the water when there is plenty in the well at home. It contains 108 pounds of ash, 64 pounds of indigestible protein, 1,250 pounds of carbohydrates, and 90 pounds of fat. It would be absurd to pay at the rate of \$10 per ton for these materials when we have more at home than we have any use for, so the logical conclusion is that the \$10 are paid for the 258 pounds of digestible protein that the ton of bran contains. When bran is used in the ration, hay may be fed as roughage, but corn stover cannot be made this part of the ration, because it contains too little protein and too much carbohydrates, and in order to be able to feed stover, mill stuffs containing a higher percentage of protein must be purchased, which decreases the value of stover in proportion to the extra amount of protein that must be purchased. Or, in other words, stover is worth as much less as its protein content is less than that in the hay. When the grain and roughage used in a ration have a low protein content, it becomes necessary to add some concentrates having a high per cent. of protein to provide the nutrients in the right proportion.

A ton of oil meal contains 184 pounds of water, 114 pounds of ash, 72 pounds of indigestible protein, 886 pounds of carbohydrates and 158 pounds of ether extract or fat. Surely no sane person would be guilty of buying these substances and paying at the rate of \$20 to \$25 per ton when he is already overstocked with them on the farm. So it must be that he is buying the digestible protein. The ton of oil meal contains 586 pounds of digestible protein, and since the cost of this nutrient in bran was 4 cents a pound, the value of a ton of oil meal is \$23.44 when bran costs \$10 per ton.

A ton of cotton seed meal contains 164 pounds of water, 144 pounds of ash, 584 pounds of carbohydrates, 252 pounds of ether extract, or fat, and 102 pounds of indigestible protein; and since all these are found in great abundance in our farm-grown feed stuffs, it follows that the ton of cotton seed meal is purchased because of the 744 pounds of digestible protein it supplies. And when this nutrient costs 4 cents per pound in other concentrates, a ton of cotton seed meal is worth \$29.76. If it is found that any farm grown feed contains enough digestible protein so that it will not be necessary to purchase any mill products, then that feed is worth as much more per ton as would have to be paid for the difference in protein if the farm feed contained a lower percentage; or, in other words, the money value of all the feed stuffs used in the ration for dairy cows depends upon the percentage of digestible protein they contain. When bran can be purchased for \$10, oil meal for \$23.44, and cotton seed meal for \$29.76, corn is worth only 21 cents per bushel, oats 12 cents and barley 18 cents; for the only nutrient needed can be purchased in bran, oil meal and cotton seed meal at these prices. If farmers will bear this in mind, they will not feed 25 cent oats, 30 cent corn, and 35 cent barley, when shorts, bran, and other by-products of the mills can be obtained at the prices quoted.

Another mistake generally made is in buying shorts for dairy cows, instead of bran; presumably because shorts are heavy. So is sand. A ton of shorts contains 236 pounds of water, 92 pounds of ash, 80 pounds of indigestible protein, 1,284 pounds of carbohydrates and 90 pounds of fat. As above stated, all these substances are in great abundance on the farm. As the digestible protein is the nutrient needed, it follows that the 218 pounds of digestible protein in the ton of shorts fixes its value; and since we can get it in the bran and oil meal at 4 cents per pound, shorts, when containing 10 per cent. of digestible protein, is worth only \$8.72 per ton for dairy cows when bran is worth \$10. It should, however, be borne in mind that these values hold good in feeding for milk only. If an animal is being fed for gain in weight, shorts would be preferable, especially in the case of feeding swine.

The same inconsistency exists in regard to the market price of roughage. Take, for example, timothy hay, and assume that it yields two tons per acre. In two tons there are 112 pounds of digestible protein, which at 4 cents per pound amounts to \$4.48 worth of protein per acre, making its feeding value \$2.24 per ton. This hay sells in our market for from \$4 to \$8 per ton. An acre of clover will produce about two tons of cured hay, containing 272 pounds of digestible protein, which at 4 cents per pound amounts to \$10.88 worth of protein per acre, making its feeding value \$5.44 per ton. An acre will produce six tons of fodder corn containing 300 pounds of digestible protein, which at 4 cents per pound makes \$12 worth of protein in the six tons of fodder corn worth \$2 per ton.

In view of these discrepancies between ruling market prices and the actual money value of feeding stuffs, we have for several years disregarded prices, and have based our calculations on the cost of digestible protein, and have fed it in whatever palatable form we found it the cheapest. It is by this method and through the decrease in the price of protein that we have reduced the cost of production.

The profit in dairying, as in any other business, depends upon the margin between the price of the product and the cost of production. It is therefore of primary importance to provide feed stuffs at the least cost, and when grain is relatively high it may become advantageous to sell it and buy mill feed.

As a rule, cows in full flow should be fed all they will eat up clean, but such generous feeding should never be inaugurated after they have advanced far in the period of lactation, because in such case they will not materially increase the flow of milk, but will commence laying on fat, which is objectionable. The reason cows should be fed all they will take is because they must first be provided with enough food for bodily maintenance, and the more they will eat and digest over and above this the more they have available for converting into product. The amount of food required for bodily maintenance depends upon the weight and disposition of the animal. The heavier the body the more food for maintenance is required and the less will there be available for product. So if a cow gains in weight each succeeding day she will need more food for support, and since increase in weight does not add to her feeding powers she will decrease in flow of milk.

That generous feeding pays is clearly illustrated in our record for the five years ending December 30, 1897. During the years 1893, 1895, 1896 and 1897, cows were fed all they would take, while during the year 1894 they were fed light.

	Milk.	Butter.	Cost of 1 lb. butter.
1893	6,407	364	10.6 cents.
1894	4,909	271	10.9 "
1895	7,418	352	8.0 "
1896	7,454	349	6.3 "
1897	6,962	351	5.4 "

These are averages of the entire herd, and show that during the four years, when receiving all they would eat up

clean, they averaged 354 pounds of butter each, while the average yield for 1894, when on comparatively light feed, was only 271 pounds. The cost of production was also the greatest that year. The kind of feed has little, if anything, to do with the yield so long as they get the required amount of nutrients in the right proportion and in palatable form. We get as much out of fodder corn as we do out of ensilage, and as much from a pound of protein in bran as from a pound of protein in any other concentrate.

They give just a trifle more milk when receiving some succulent feed, such as roots and ensilage, but practically the same amount of butter or other milk solids. We select the cheapest foods and so mix them that the cow gets about one pound of digestible protein to six pounds of carbohydrates. If we should feed a much wider ration—that is, one that contained more carbohydrates and carbohydrate equivalent than the amount stated—she would gradually lay on fat, shrink in milk, and failure to breed would probably follow; but when the above mentioned nutritive ratio is maintained, no such difficulties are encountered.

Our records show that radical changes in feed during the winter are objectionable, as changes generally cause shrinkage in milk. A more uniform flow is maintained by feeding the same ration all winter, if possible. If it becomes necessary to make a change it should be very gradual, so the system can adjust itself to the variation in bulk and the muscular action required by the stomach to digest that particular ration.

COMPOSITION OF FEEDING STUFFS.

The following tables give the digestible protein, carbohydrates, and fat contained in 100 pounds each of the feed stuffs commonly used, with their comparative value for dairy cows, calculations being based upon the per cent. of digestible protein.

TABLE OXXX.—Giving Composition and Comparative Value of Feed Stuffs for Dairy Cows.

	Composition, 100 Lbs.				Comparative Value Per Ton when Timothy is Worth						
	Dry Matter	Digestible			\$5	\$6	\$7	\$8	\$9	\$11	\$13
		Pro.	C.-H.	Fat							
GREEN FODDER—											
Corn Fodder.....	20.70	1.0	11.6	0.4	1.79	2.14	2.50	2.86	3.21	3.93	4.64
Oat Fodder.....	37.80	2.6	18.9	1.0	4.64	5.57	6.50	7.43	8.36	10.21	12.07
Pea Fodder.....	32.86	3.0	16.7	0.6	5.36	6.43	7.50	8.57	9.64	11.78	13.93
Red Clover.....	29.20	2.9	14.8	0.7	5.18	6.21	7.25	8.29	9.32	11.39	13.46
Sorghum.....	20.60	0.6	12.2	0.4	1.07	1.29	1.50	1.71	1.93	2.36	2.79
SILAGE—											
Corn.....	20.90	0.9	11.3	0.7	1.61	1.93	2.25	2.57	2.89	3.54	4.18
Sorghum.....	23.90	0.6	14.9	0.2	1.07	1.29	1.50	1.71	1.93	2.36	2.79
ROUGHAGE (FIELD CURED)—											
Corn Fodder.....	57.80	2.5	34.6	1.2	4.46	5.35	6.25	7.14	8.03	9.82	11.61
Corn Stover.....	59.50	1.7	32.4	0.7	3.04	3.64	4.25	4.86	5.46	6.68	7.89
Sorghum.....	50.30	2.4	32.1	1.6	4.28	5.14	6.00	6.85	7.72	9.43	11.14
Timothy.....	86.80	2.8	43.4	1.4	5.00	6.00	7.00	8.00	9.00	11.00	13.00
Alfalfa.....	91.60	1.0	39.6	1.2	19.65	23.56	27.50	31.43	35.35	43.21	51.07
Alfalfa Clover.....	90.30	8.4	42.5	1.5	15.00	18.00	21.00	24.00	27.00	33.00	39.00
Red Clover.....	84.70	6.8	35.8	1.7	12.14	14.57	17.00	19.43	21.86	26.71	31.57
Millet.....	88.00	3.2	48.5	1.0	5.72	6.85	8.00	9.14	10.28	12.57	14.86
Orchard Grass.....	90.10	4.9	42.3	1.4	8.75	10.50	12.25	14.00	15.75	19.25	22.75
Prairie, Upland.....	87.50	3.0	41.8	1.4	5.36	6.43	7.50	8.57	9.64	11.78	13.93
Prairie, Mix'd.....	84.10	2.9	41.5	1.2	5.18	6.21	7.25	8.29	9.32	11.39	13.46
Prairie, Swale.....	86.30	2.6	41.9	1.1	4.64	5.57	6.50	7.43	8.36	10.21	12.07
Red Top.....	91.10	4.8	46.9	1.0	8.57	10.28	12.00	13.71	15.43	18.85	22.29
Sedge Grass.....	89.84	2.7	45.3	1.1	4.82	5.78	6.75	7.51	8.68	10.61	12.54
Soja Bean.....	86.70	10.8	38.7	1.5	19.29	23.13	27.00	30.83	34.71	42.42	50.14
Cow Pea.....	89.30	10.8	38.6	1.1	19.29	23.13	27.00	30.83	34.71	42.42	50.14
Pea Hay.....	90.25	8.00	41.1	1.7	14.28	17.16	20.02	22.88	25.74	31.46	37.18
Oats.....	91.10	4.3	46.4	1.5	7.68	9.21	10.75	12.29	13.82	16.89	19.96
Wheat Straw.....	90.40	0.4	36.3	0.4	2.14	2.57	3.00	3.42	3.86	4.71	5.57
Oat Straw.....	90.80	1.2	36.6	0.8	2.14	2.57	3.00	3.42	3.86	4.71	5.57
Rye Straw.....	92.90	0.6	40.6	0.4	1.07	1.29	1.50	1.71	1.93	2.36	2.79
ROOTS AND TUBERS—											
Potatoes.....	21.10	0.9	16.3	0.1	1.61	1.93	2.25	2.57	2.89	3.54	4.18
Sugar Beets.....	18.50	1.1	10.2	0.1	1.96	2.36	2.76	3.14	3.53	4.32	5.11
Mangels.....	9.10	1.1	5.4	0.1	1.96	2.36	2.76	3.14	3.53	4.32	5.11
Turnips.....	9.50	1.0	7.2	0.2	1.79	2.14	2.50	2.86	3.21	3.93	4.64
Ruta-bages.....	11.40	1.0	8.1	0.2	1.79	2.14	2.50	2.86	3.21	3.93	4.64
Carrots.....	11.40	0.8	7.8	0.2	1.43	1.71	2.00	2.29	2.57	3.14	3.71
Beet Pulp.....	10.20	0.6	7.3	0.1	1.07	1.29	1.50	1.71	1.93	2.36	2.79

TABLE CXXX.—Giving Composition and Comparative Value of Feed Stuffs for Dairy Cows.—Continued.

Composition, 100 Lbs.					Comparative Value Per Ton when Bran is Worth						
Dry Matter	Digestible				\$5	\$6	\$7	\$8	\$9	\$11	\$13
	Pro.	C. H.	Fat								
BY-PRODUCTS—											
Bran.....	88.50	12.9	40.1	3.4	5.00	6.00	7.00	8.00	9.00	11.00	13.00
Buckwheat Shorts.....	88.90	21.1	33.5	5.5	8.18	9.81	11.44	13.08	14.72	17.99	21.76
Cotton Seed Meal.....	91.80	27.2	35.7	32.2	14.42	7.80	20.18	28.07	35.95	47.99	57.48
Oat Meal.....	90.80	29.3	32.7	7.0	11.26	15.63	15.89	19.17	20.44	24.98	29.52
Gluten Meal.....	91.80	25.8	43.3	11.0	10.00	12.00	14.00	16.00	18.00	22.00	26.00
Gluten.....	89.60	29.7	31.2	6.2	3.49	4.19	4.88	5.58	6.28	7.97	9.07
Graino-Gluten.....	94.30	26.7	32.8	12.4	10.33	12.42	14.49	16.56	18.63	22.77	26.91
Glucose Meal.....	91.80	30.3	33.3	14.5	11.76	7.10	16.45	18.50	21.15	23.85	30.55
Brewers' Grains (Unfed).....	91.80	16.7	36.3	5.1	6.09	7.30	8.52	9.74	10.96	13.39	15.82
Brewers' Grains (Fed).....	24.30	3.9	39.3	1.4	1.51	1.81	2.12	2.42	2.72	3.33	3.93
Malt Shorts.....	89.80	18.6	37.1	1.7	7.21	8.65	10.09	11.53	12.98	15.86	18.74
Wheat Shorts.....	88.20	12.2	50.0	3.8	4.73	5.67	6.62	7.57	8.51	10.40	12.29
GRAINS AND OTHER SEEDS—											
Barley.....	89.10	8.7	65.6	1.6	3.37	4.05	4.72	5.40	6.07	7.42	8.77
Corn.....	89.10	7.9	66.7	4.3	3.06	3.67	4.29	4.90	5.51	6.74	7.96
Corn and Cob Meal.....	84.90	4.4	60.0	2.9	1.71	2.05	2.39	2.73	3.07	3.75	4.43
Millet Seed.....	86.00	8.9	45.0	3.2	3.45	4.14	4.83	5.52	6.21	7.59	8.97
Flax Seed Meal.....	90.80	20.6	17.1	29.0	7.98	5.58	11.17	12.77	14.37	17.56	20.76
Oats.....	89.00	9.2	47.3	4.2	3.57	4.28	4.99	5.71	6.42	7.84	9.27
Pean.....	89.50	16.8	51.8	0.7	6.51	7.81	9.12	10.41	11.72	14.33	16.93
Rye.....	88.40	9.9	67.6	1.1	3.84	4.60	5.37	6.14	6.91	8.44	9.98
Wheat.....	89.50	10.2	69.2	1.7	3.95	4.74	5.53	6.33	7.12	8.70	10.28
Value Per Bushel on Above Basis.											
Barley.....	Cents	Cents	Cents	Cents	8.1	9.7	11.3	13.0	14.6	17.8	21.0
Corn.....	8.1	9.7	11.3	13.0	8.6	10.3	12.0	13.7	15.4	18.9	22.3
Millet Seed.....	8.3	9.9	11.6	13.2	5.7	6.8	8.0	9.1	10.8	12.5	14.8
Oats.....	5.7	6.8	8.0	9.1	19.5	23.4	27.4	31.2	35.2	43.0	50.8
Pean.....	10.8	12.9	15.0	17.2	11.9	14.2	16.6	19.0	21.4	26.1	30.8
Rye.....	11.9	14.2	16.6	19.0							
Wheat.....											

NOTE.—"Pro." is the abbreviation of Protein, "C. H." of Carbohydrates, and "Fat" means Ether Extract.

Since the prices of farm products are governed by the laws of supply and demand, and not by their actual money value as feed stuffs, it often happens that certain products can be sold for more than their value as food for milk production and others bought for less than their feeding value. To aid in selecting the most economical food the following tables have been arranged, giving the comparative value of the grains ordinarily grown on the farm, calculations being based on the percentage of digestible protein:

Protein in Corn as a Basis.

	When Corn is worth per bushel							
	16 Cts.	18 Cts.	20 Cts.	22 Cts.	24 Cts.	26 Cts.	28 Cts.	30 Cts.
Barley.....	15.1	17.0	18.9	20.8	22.7	24.5	26.4	28.3
Oats.....	10.6	12.0	13.3	14.6	16.0	17.3	18.6	20.0
Rye.....	20.0	22.6	25.1	27.6	30.1	32.6	35.1	37.6
Wheat.....	22.1	24.8	27.6	30.4	33.1	35.9	38.6	41.4
Bran..... per ton	\$ 9.33	\$10.46	\$11.64	\$12.81	\$13.95	\$15.13	\$16.33	\$17.47
Linseed Meal...	21.18	23.82	26.49	29.16	31.76	34.43	37.10	39.77
Cotton Seed Meal "	26.89	30.24	33.63	37.02	40.32	43.71	47.10	50.49
Gluten Meal..... "	18.66	20.92	23.28	25.62	27.90	30.26	32.66	34.94

Protein in Barley as a Basis.

	When Barley is worth per bushel							
	16 Cts.	18 Cts.	20 Cts.	22 Cts.	24 Cts.	26 Cts.	28 Cts.	30 Cts.
Corn.....	16.9	19.1	21.2	23.3	25.4	27.5	29.7	31.8
Oats.....	11.3	12.7	14.1	15.5	16.9	18.3	19.7	21.2
Rye.....	21.2	23.9	26.6	29.2	31.9	34.5	37.2	39.8
Wheat.....	23.4	26.4	29.3	32.2	35.2	38.1	41.0	44.0
Bran..... per ton	\$ 9.88	\$11.12	\$12.37	\$13.58	\$14.83	\$16.08	\$17.29	\$18.54
Linseed Meal...	22.44	25.27	28.11	30.87	33.70	36.53	39.29	42.12
Cotton Seed Meal "	28.44	32.02	35.61	39.11	42.70	46.29	49.79	53.17
Gluten Meal..... "	19.76	22.24	24.74	27.16	29.66	32.16	34.58	37.08

FEEDING DAIRY COWS.

Protein in Oats as a Basis.

	When Oats are worth per bushel							
	16 Cts.	18 Cts.	20 Cts.	22 Cts.	24 Cts.	26 Cts.	28 Cts.	30 Cts.
Barley.....	22.7	25.6	28.4	31.2	34.1	36.9	39.8	42.6
Corn.....	24.0	27.1	30.1	33.1	36.1	39.1	42.1	45.1
Rye.....	30.1	33.9	37.7	41.4	45.2	49.0	52.7	56.5
Wheat.....	33.8	37.4	41.6	45.8	49.9	54.1	58.2	62.4
Bran.....per ton	\$14.02	\$15.76	\$17.52	\$19.28	\$21.03	\$22.77	\$24.53	\$26.27
Linseed Meal...	31.80	35.74	39.75	43.69	47.70	51.64	55.65	59.59
Cotton Seed Meal "	40.40	45.41	50.50	55.51	60.60	65.61	70.70	75.71
Gluten Meal..... "	28.04	31.52	35.04	38.52	42.06	45.54	49.06	52.54

Protein in Rye as a Basis.

	When Rye is worth per bushel							
	16 Cts.	18 Cts.	20 Cts.	22 Cts.	24 Cts.	26 Cts.	28 Cts.	30 Cts.
Barley.....	12.0	13.6	15.1	16.6	18.1	19.6	21.1	22.6
Corn.....	12.8	14.4	16.0	17.6	19.2	20.7	22.3	23.9
Oats.....	8.5	9.6	10.6	11.7	12.7	13.8	14.9	15.9
Wheat.....	17.6	19.8	22.0	24.2	26.4	28.6	30.8	33.0
Bran.....per ton	\$ 6.44	\$ 8.35	\$ 9.28	\$10.22	\$11.13	\$12.06	\$13.00	\$13.94
Linseed Meal...	16.93	19.00	21.13	23.26	25.34	27.47	29.60	31.73
Cotton Seed Meal "	21.52	24.14	26.85	29.55	32.18	34.89	37.60	40.31
Gluten Meal..... "	12.88	16.70	18.56	20.44	22.26	24.12	26.00	27.88

The tables following show the dry matter and digestible nutrients contained in a given number of pounds of the food stuffs commonly used in the northwest. For roughage calculations are made from 5 to 20 pounds, inclusive, except for the straws, which are made from 1 to 5 pounds, inclusive. For the grains, bran and shorts, calculations are made from 1 to 10 pounds, and for the other concentrates from 1 to 5 pounds, inclusive.

TABLE CXXXI.—Giving Pounds of Dry Matter and Digestible Nutrients Contained in a Given Number of Pounds of Food Stuff.

LBS.	CORN FODDER				CORN STOVER				SORGHUM FODDER			
	COMPOSITION				COMPOSITION				COMPOSITION			
	Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE		
		Pro.	C. H.	Fat		Pro.	C. H.	Fat		Pro.	C. H.	Fat
5.....	2.89	.125	1.730	.060	2.97	.085	1.620	.035	2.51	.120	1.605	.080
6.....	3.47	.150	2.076	.072	3.57	.102	1.944	.042	3.02	.144	1.926	.096
7.....	4.05	.175	2.422	.084	4.16	.119	2.268	.049	3.52	.168	2.247	.112
8.....	4.62	.200	2.768	.096	4.76	.136	2.592	.056	4.02	.192	2.568	.128
9.....	5.20	.225	3.114	.108	5.35	.153	2.916	.063	4.58	.216	2.889	.144
10.....	5.78	.250	3.460	.120	5.95	.170	3.240	.070	5.03	.240	3.210	.160
11.....	6.36	.275	3.806	.132	6.54	.187	3.564	.077	5.58	.264	3.531	.176
12.....	6.94	.300	4.152	.144	7.14	.204	3.888	.084	6.04	.288	3.852	.192
13.....	7.51	.325	4.498	.156	7.73	.221	4.212	.091	6.54	.312	4.173	.208
14.....	8.09	.350	4.844	.168	8.33	.238	4.536	.098	7.04	.336	4.494	.224
15.....	8.67	.375	5.190	.180	8.92	.255	4.860	.105	7.54	.360	4.815	.240
16.....	9.25	.400	5.536	.192	9.52	.272	5.184	.112	8.05	.384	5.136	.256
17.....	9.83	.425	5.882	.204	10.11	.289	5.508	.119	8.55	.408	5.457	.272
18.....	10.40	.450	6.228	.216	10.71	.306	5.832	.126	9.05	.432	5.778	.288
19.....	10.98	.475	6.574	.228	11.30	.323	6.156	.133	9.56	.456	6.099	.304
20.....	11.56	.500	6.920	.240	11.90	.340	6.480	.140	10.06	.480	6.420	.320

LBS.	TIMOTHY				RED TOP				MILLET			
5.....	4.34	.140	2.170	.070	4.55	.240	2.345	.05	4.40	.160	2.425	.05
6.....	5.21	.168	2.604	.084	5.47	.288	2.814	.06	5.28	.192	2.910	.06
7.....	6.08	.196	3.038	.098	6.38	.336	3.283	.07	6.16	.224	3.395	.07
8.....	6.94	.224	3.472	.112	7.29	.384	3.752	.08	7.04	.256	3.880	.08
9.....	7.81	.252	3.906	.126	8.20	.432	4.221	.09	7.92	.288	4.365	.09
10.....	8.68	.280	4.340	.140	9.11	.480	4.690	.10	8.80	.320	4.850	.10
11.....	9.55	.308	4.774	.154	10.02	.528	5.159	.11	9.68	.352	5.335	.11
12.....	10.42	.336	5.208	.168	10.93	.576	5.628	.12	10.56	.384	5.820	.12
13.....	11.28	.364	5.642	.182	11.84	.624	6.097	.13	11.44	.416	6.305	.13
14.....	12.15	.392	6.076	.196	12.75	.672	6.566	.14	12.32	.448	6.790	.14
15.....	13.02	.420	6.510	.210	13.66	.720	7.035	.15	13.20	.480	7.275	.15
16.....	13.89	.448	6.904	.224	14.58	.768	7.504	.16	14.08	.512	7.760	.16
17.....	14.76	.476	7.378	.238	15.49	.816	7.973	.17	14.96	.544	8.245	.17
18.....	15.62	.504	7.812	.252	16.40	.864	8.442	.18	15.84	.576	8.780	.18
19.....	16.42	.532	8.246	.266	17.31	.912	8.911	.19	16.72	.608	9.215	.19
20.....	17.28	.560	8.680	.280	18.22	.960	9.380	.20	17.60	.640	9.700	.20

LBS.	PRAIRIE HAY, Upland				PRAIRIE HAY, Mixed				PRAIRIE HAY, Swale			
5.....	4.37	.15	2.090	.070	4.20	.145	2.075	.060	4.31	.130	2.095	.055
6.....	5.25	.18	2.508	.084	5.05	.174	2.490	.072	5.18	.156	2.514	.066
7.....	6.12	.21	2.926	.098	5.89	.203	2.905	.084	6.04	.182	2.933	.077
8.....	7.00	.24	3.344	.112	6.73	.232	3.320	.096	6.90	.208	3.352	.088
9.....	7.87	.27	3.762	.126	7.57	.261	3.735	.108	7.77	.234	3.771	.099
10.....	8.75	.30	4.180	.140	8.41	.290	4.150	.120	8.63	.260	4.190	.110
11.....	9.62	.33	4.598	.154	9.25	.319	4.565	.132	9.49	.286	4.609	.121
12.....	10.50	.36	5.018	.168	10.09	.348	4.980	.144	10.86	.312	5.028	.132
13.....	11.37	.39	5.434	.182	10.93	.377	5.395	.156	11.22	.338	5.447	.143
14.....	12.25	.42	5.852	.196	11.77	.406	5.810	.168	12.08	.364	5.866	.154
15.....	13.12	.45	6.270	.210	12.61	.435	6.225	.180	12.94	.390	6.285	.165
16.....	14.00	.48	6.688	.224	13.52	.464	6.640	.192	13.81	.416	6.704	.176
17.....	14.87	.51	7.106	.238	14.36	.493	7.055	.204	14.67	.442	7.128	.187
18.....	15.76	.54	7.524	.252	15.21	.522	7.470	.216	15.53	.468	7.542	.198
19.....	16.62	.57	7.942	.266	16.05	.551	7.885	.228	16.40	.494	7.951	.209
20.....	17.50	.60	8.360	.280	16.90	.580	8.300	.240	17.26	.520	8.380	.220

TABLE CXXXI.—Giving Pounds of Dry Matter and Digestible Nutrients Contained in a Given Number of Pounds of Food Stuff.—Continued.

LBS.	SEDGE HAY				OAT HAY				SOJA BEAN HAY			
	COMPOSITION				COMPOSITION				COMPOSITION			
	Dry Mat-ter	DIGESTIBLE			Dry Mat-ter	DIGESTIBLE			Dry Mat-ter	DIGESTIBLE		
		Pro.	C. H.	Fat		Pro.	C. H.	Fat		Pro.	C. H.	Fat
5.....	4.49	.185	2.265	.055	4.55	.215	2.320	.075	4.43	.540	1.935	.075
6.....	5.39	.162	2.718	.066	5.47	.258	2.784	.090	5.82	.648	2.322	.090
7.....	6.29	.189	3.171	.077	6.38	.301	3.248	.105	6.21	.756	2.709	.105
8.....	7.19	.216	3.624	.088	7.29	.344	3.712	.120	7.10	.864	3.096	.120
9.....	8.09	.243	4.077	.099	8.20	.387	4.176	.135	7.98	.972	3.483	.135
10.....	8.98	.270	4.530	.110	9.11	.430	4.640	.150	8.87	1.080	3.870	.150
11.....	9.88	.297	4.983	.121	10.02	.473	5.104	.165	9.76	1.188	4.257	.165
12.....	10.78	.324	5.436	.132	10.93	.516	5.568	.180	10.64	1.296	4.644	.180
13.....	11.68	.351	5.889	.143	11.84	.559	6.032	.195	11.53	1.404	5.031	.195
14.....	12.58	.378	6.342	.154	12.75	.602	6.496	.210	12.42	1.512	5.418	.210
15.....	13.48	.405	6.785	.165	13.66	.645	6.960	.225	13.30	1.620	5.806	.225
16.....	14.38	.432	7.248	.176	14.58	.688	7.424	.240	14.19	1.728	6.192	.240
17.....	15.28	.459	7.701	.187	15.49	.731	7.888	.255	15.08	1.836	6.579	.255
18.....	16.17	.486	8.154	.198	16.40	.774	8.352	.270	15.97	1.944	6.966	.270
19.....	17.07	.513	8.607	.209	17.31	.817	8.816	.285	16.85	2.052	7.353	.285
20.....	17.97	.540	9.060	.220	18.22	.860	9.280	.300	17.74	2.160	7.740	.300

LB3.	ALFALFA HAY				ALSIKE HAY				RED CLOVER HAY			
5.....	4.58	.55	1.980	.060	4.51	.420	2.125	.075	4.28	.340	1.790	.085
6.....	5.50	.66	2.376	.072	5.42	.504	2.560	.090	5.08	.408	2.148	.102
7.....	6.41	.77	2.772	.084	6.32	.588	2.975	.105	5.93	.476	2.506	.119
8.....	7.33	.88	3.168	.096	7.22	.672	3.400	.120	6.78	.544	2.864	.136
9.....	8.24	.99	3.564	.108	8.13	.756	3.825	.135	7.62	.612	3.222	.153
10.....	9.16	1.10	3.960	.120	9.03	.840	4.250	.150	8.47	.680	3.580	.170
11.....	10.08	1.21	4.356	.132	9.93	.924	4.675	.165	9.32	.748	3.938	.187
12.....	10.99	1.32	4.752	.144	10.84	1.008	5.100	.180	10.16	.816	4.296	.204
13.....	11.91	1.43	5.148	.156	11.74	1.092	5.525	.195	11.01	.884	4.654	.221
14.....	12.82	1.54	5.544	.168	12.64	1.176	5.950	.210	11.86	.952	5.012	.238
15.....	13.74	1.65	5.940	.180	13.54	1.260	6.375	.225	12.70	1.020	5.370	.255
16.....	14.66	1.76	6.336	.192	14.45	1.344	6.800	.240	13.55	1.088	5.728	.272
17.....	15.57	1.87	6.732	.204	15.35	1.428	7.225	.255	14.40	1.156	6.086	.289
18.....	16.49	1.98	7.128	.216	16.25	1.512	7.650	.270	15.25	1.224	6.444	.306
19.....	17.40	2.09	7.524	.228	17.16	1.596	8.075	.285	16.09	1.292	6.802	.323
20.....	18.32	2.20	7.920	.240	18.06	1.680	8.500	.300	16.94	1.360	7.160	.340

LBS.	WHEAT STRAW				OAT STRAW				RYE STRAW			
1.....	.904	.004	.363	.004	.908	.012	.386	.008	.929	.006	.406	.004
2.....	1.808	.008	.726	.008	1.816	.024	.772	.016	1.858	.012	.812	.008
3.....	2.712	.012	1.089	.012	2.724	.036	1.158	.024	2.787	.018	1.218	.012
4.....	3.616	.016	1.452	.016	3.632	.048	1.544	.032	3.716	.024	1.624	.016
5.....	4.520	.020	1.815	.020	4.540	.060	1.930	.040	4.645	.030	2.030	.020

TABLE CXXXI.—Giving Pounds of Dry Matter and Digestible Nutrients Contained in a Given Number of Pounds of Food Stuff.—Continued.

LBS.	CORN SILAGE				SORGHUM SILAGE				CLOVER SILAGE			
	COMPOSITION				COMPOSITION				COMPOSITION			
	Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE		
		Pro.	C. H.	Fat		Pro.	C. H.	Fat		Pro.	C. H.	Fat
10.....	2.09	.090	1.130	.070	2.39	.060	1.490	.020	2.80	.200	1.350	.100
11.....	2.30	.099	1.243	.077	2.63	.066	1.639	.022	3.08	.220	1.485	.110
12.....	2.51	.108	1.356	.084	2.87	.072	1.788	.024	3.36	.240	1.520	.120
13.....	2.72	.117	1.469	.091	3.11	.078	1.937	.026	3.64	.260	1.755	.130
14.....	2.98	.126	1.582	.098	3.35	.084	2.086	.028	3.92	.280	1.890	.140
15.....	3.13	.135	1.695	.105	3.58	.090	2.235	.030	4.20	.300	2.025	.150
16.....	3.34	.144	1.808	.112	3.82	.096	2.384	.032	4.48	.320	2.160	.160
17.....	3.55	.153	1.921	.119	4.06	.102	2.533	.034	4.76	.340	2.295	.170
18.....	3.76	.162	2.034	.126	4.30	.108	2.682	.036	5.04	.360	2.430	.180
19.....	3.97	.171	2.147	.133	4.54	.114	2.831	.038	5.32	.380	2.565	.190
20.....	4.18	.180	2.260	.140	4.78	.120	2.980	.040	5.60	.400	2.700	.200
21.....	4.39	.189	2.373	.147	5.02	.126	3.129	.042	5.88	.420	2.835	.210
22.....	4.60	.198	2.486	.154	5.26	.132	3.278	.044	6.16	.440	2.970	.220
23.....	4.81	.207	2.599	.161	5.50	.138	3.427	.046	6.44	.460	3.105	.230
24.....	5.02	.216	2.712	.168	5.74	.144	3.576	.048	6.72	.480	3.240	.240
25.....	5.22	.225	2.825	.175	5.97	.150	3.725	.050	7.00	.500	3.375	.250
26.....	5.43	.234	2.938	.182	6.21	.156	3.874	.052	7.28	.520	3.510	.260
27.....	5.64	.243	3.051	.189	6.45	.162	4.023	.054	7.56	.540	3.645	.270
28.....	5.85	.252	3.164	.196	6.69	.168	4.172	.056	7.84	.560	3.780	.280
29.....	6.06	.261	3.277	.203	6.93	.174	4.321	.058	8.12	.580	3.915	.290
30.....	6.27	.270	3.390	.210	7.17	.180	4.470	.060	8.40	.600	4.050	.300
31.....	6.48	.279	3.503	.217	7.41	.186	4.619	.062	8.68	.620	4.185	.310
32.....	6.69	.288	3.616	.224	7.65	.192	4.768	.064	8.96	.640	4.320	.320
33.....	6.90	.297	3.729	.231	7.89	.198	4.917	.066	9.24	.660	4.455	.330
34.....	7.11	.306	3.842	.238	8.13	.204	5.066	.068	9.52	.680	4.590	.340
35.....	7.31	.315	3.955	.245	8.36	.210	5.215	.070	9.80	.700	4.725	.350
36.....	7.52	.324	4.068	.252	8.60	.216	5.364	.072	10.08	.720	4.860	.360
37.....	7.73	.333	4.181	.259	8.84	.222	5.513	.074	10.36	.740	4.995	.370
38.....	7.94	.342	4.294	.266	9.08	.228	5.662	.076	10.64	.760	5.130	.380
39.....	8.15	.351	4.407	.273	9.32	.234	5.811	.078	10.92	.780	5.265	.390
40.....	8.36	.360	4.520	.280	9.56	.240	5.960	.080	11.20	.800	5.400	.400

LBS.	SUGAR BEETS				MANGELS				RUTA-BAGAS			
5.....	.678	.055	.510	.005	.455	.055	.270	.005	.570	.050	.405	.010
6.....	.810	.066	.612	.006	.546	.066	.324	.006	.684	.060	.486	.012
7.....	.945	.077	.714	.007	.637	.077	.378	.007	.798	.070	.567	.014
8.....	1.085	.088	.816	.008	.728	.088	.432	.008	.912	.080	.648	.016
9.....	1.215	.099	.918	.009	.819	.099	.486	.009	1.026	.090	.729	.018
10.....	1.350	.110	1.020	.010	.910	.110	.540	.010	1.140	.100	.810	.020
11.....	1.485	.121	1.122	.011	1.001	.121	.594	.011	1.254	.110	.891	.022
12.....	1.620	.132	1.224	.012	1.092	.132	.648	.012	1.368	.120	.972	.024
13.....	1.755	.143	1.326	.013	1.183	.143	.702	.013	1.482	.130	1.053	.026
14.....	1.890	.154	1.428	.014	1.274	.154	.756	.014	1.596	.140	1.134	.028
15.....	2.025	.165	1.530	.015	1.365	.165	.810	.015	1.710	.150	1.215	.030
16.....	2.160	.176	1.632	.016	1.456	.176	.864	.016	1.824	.160	1.296	.032
17.....	2.295	.187	1.734	.017	1.547	.187	.918	.017	1.938	.170	1.377	.034
18.....	2.430	.198	1.836	.018	1.638	.198	.972	.018	2.052	.180	1.458	.036
19.....	2.565	.209	1.938	.019	1.729	.209	1.026	.019	2.166	.190	1.539	.038
20.....	2.700	.220	2.040	.020	1.820	.220	1.080	.020	2.280	.200	1.620	.040

TABLE CXXXI.—Giving Pounds of Dry Matter and Digestible Nutrients Contained in a Given Number of Pounds of Food Stuff.—Continued.

LBS.	BARLEY				CORN				OATS			
	COMPOSITION				COMPOSITION				COMPOSITION			
	Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE			Dry Matter	DIGESTIBLE		
		Pro.	C. H.	Fat		Pro.	C. H.	Fat		Pro.	C. H.	Fat
1.....	.89	.087	.656	.016	.89	.079	.667	.043	.89	.092	.473	.042
2.....	1.78	.174	1.312	.032	1.78	.158	1.334	.086	1.78	.184	.946	.084
3.....	2.67	.261	1.968	.048	2.67	.237	2.001	.129	2.67	.276	1.419	.126
4.....	3.56	.348	2.624	.064	3.56	.316	2.668	.172	3.56	.368	1.892	.168
5.....	4.45	.435	3.280	.080	4.45	.395	3.385	.215	4.45	.460	2.365	.210
6.....	5.35	.522	3.936	.096	5.35	.474	4.002	.258	5.34	.552	2.838	.252
7.....	6.24	.609	4.592	.112	6.24	.553	4.669	.301	6.23	.644	3.311	.294
8.....	7.13	.696	5.248	.128	7.13	.632	5.336	.344	7.13	.736	3.784	.336
9.....	8.02	.783	5.904	.144	8.02	.711	6.008	.387	8.01	.828	4.257	.378
10.....	8.91	.870	6.560	.160	8.91	.790	6.670	.430	8.90	.920	4.730	.420
LBS.	CORN and COB MEAL				RYE				BREWERS' GRAINS, DRIED			
1.....	.85	.044	.60	.029	.88	.099	.676	.011	.92	.167	.363	.051
2.....	1.70	.088	1.20	.058	1.77	.198	1.352	.022	1.84	.314	.726	.102
3.....	2.55	.132	1.80	.087	2.65	.297	2.028	.033	2.75	.471	1.089	.153
4.....	3.40	.176	2.40	.116	3.54	.396	2.704	.044	3.67	.628	1.452	.204
5.....	4.24	.220	3.00	.145	4.42	.495	3.380	.055	4.59	.785	1.815	.253
6.....	5.09	.264	3.60	.174	5.30	.594	4.056	.066	5.51	.942	2.178	.306
7.....	5.94	.308	4.20	.203	6.19	.693	4.732	.077	6.43	1.099	2.541	.357
8.....	6.79	.352	4.80	.232	7.07	.792	5.408	.088	7.34	1.256	2.904	.408
9.....	7.64	.396	5.40	.261	7.96	.891	6.084	.099	8.26	1.413	3.267	.459
10.....	8.49	.440	6.00	.290	8.84	.990	6.760	.110	9.18	1.570	3.630	.510
LBS.	WHEAT				BRAN				SHORTS			
1.....	.89	.105	.692	.017	.88	.129	.401	.034	.88	.122	.50	.038
2.....	1.79	.210	1.384	.034	1.77	.258	.802	.068	1.76	.244	1.00	.076
3.....	2.68	.315	2.076	.051	2.65	.387	1.203	.102	2.65	.366	1.50	.114
4.....	3.58	.420	2.768	.068	3.54	.516	1.604	.136	3.53	.488	2.00	.152
5.....	4.47	.525	3.460	.085	4.42	.645	2.005	.170	4.41	.610	2.50	.190
6.....	5.37	.630	4.152	.102	5.31	.774	2.406	.204	5.29	.732	3.00	.228
7.....	6.26	.735	4.844	.119	6.19	.903	2.807	.238	6.17	.854	3.50	.266
8.....	7.16	.840	5.536	.136	7.08	1.032	3.208	.272	7.05	.976	4.00	.304
9.....	8.05	.945	6.228	.153	7.96	1.161	3.609	.306	7.94	1.098	4.50	.342
10.....	8.95	1.050	6.920	.170	8.85	1.290	4.010	.340	8.82	1.220	5.00	.380
LBS.	COTTON SEED MEAL				OIL MEAL				GLUTEN MEAL			
1.....	.92	.372	.169	.122	.91	.293	.327	.07	.92	.258	.433	.110
2.....	1.84	.744	.338	.244	1.82	.586	.654	.14	1.84	.516	.866	.220
3.....	2.76	1.116	.507	.366	2.72	.879	.981	.21	2.76	.774	1.299	.330
4.....	3.67	1.488	.676	.488	3.63	1.172	1.308	.28	3.67	1.032	1.732	.440
5.....	4.59	1.860	.845	.610	4.54	1.465	1.635	.35	4.59	1.290	2.165	.550
LBS.	BUCKWHEAT SHORTS				GERM MEAL				PEAS			
1.....	.89	.211	.335	.055	.90	.09	.612	.062	.89	.168	.518	.007
2.....	1.78	.422	.670	.110	1.79	.18	1.224	.124	1.79	.336	1.036	.014
3.....	2.67	.633	1.005	.165	2.69	.27	1.836	.186	2.68	.504	1.554	.021
4.....	3.56	.844	1.340	.220	3.58	.36	2.448	.248	3.58	.672	2.072	.028
5.....	4.45	1.055	1.675	.275	4.48	.45	3.060	.310	4.47	.840	2.590	.035

TABLE CXXXII.—Giving Cost of One Pound at a Given Price and Weight per Bushel.

When a Bushel Costs	When a Bushel Weighs									
	32	42	46	48	50	52	56	58	60	70
	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs	Lbs. Costs
Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
10.....	.312	.237	.217	.208	.20	.192	.178	.172	.167	.143
11.....	.344	.262	.239	.229	.22	.212	.196	.189	.183	.167
12.....	.375	.286	.261	.250	.24	.231	.214	.207	.200	.171
13.....	.406	.309	.283	.271	.26	.250	.232	.224	.217	.186
14.....	.437	.333	.304	.292	.28	.269	.250	.241	.233	.200
15.....	.469	.357	.326	.312	.30	.288	.268	.259	.250	.214
16.....	.500	.381	.348	.333	.32	.308	.286	.276	.267	.228
17.....	.531	.405	.369	.354	.34	.327	.304	.293	.283	.243
18.....	.562	.428	.391	.375	.36	.346	.321	.310	.300	.257
19.....	.594	.452	.413	.396	.38	.365	.339	.327	.317	.271
20.....	.625	.476	.435	.417	.40	.385	.357	.345	.333	.286
21.....	.656	.500	.456	.437	.42	.404	.375	.362	.350	.300
22.....	.687	.524	.478	.458	.44	.423	.393	.379	.367	.314
23.....	.719	.547	.500	.479	.46	.442	.411	.396	.383	.328
24.....	.750	.571	.522	.500	.48	.461	.428	.414	.400	.343
25.....	.781	.595	.544	.521	.50	.481	.446	.431	.417	.357
26.....	.812	.619	.565	.542	.52	.500	.464	.448	.433	.371
27.....	.844	.643	.587	.563	.54	.519	.482	.465	.450	.386
28.....	.875	.667	.609	.583	.56	.538	.500	.483	.467	.400
29.....	.906	.690	.630	.604	.58	.558	.518	.500	.483	.414
30.....	.937	.714	.652	.625	.60	.577	.536	.517	.500	.428
31.....	.969	.738	.674	.646	.62	.596	.554	.534	.517	.443
32.....	1.000	.762	.696	.667	.64	.615	.571	.552	.533	.457
33.....	1.031	.787	.717	.687	.66	.635	.589	.569	.550	.471
34.....	1.062	.809	.739	.708	.68	.654	.607	.586	.567	.486
35.....	1.094	.833	.761	.729	.70	.673	.625	.603	.583	.506
36.....	1.125	.857	.783	.750	.72	.692	.643	.620	.600	.514
37.....	1.156	.881	.804	.771	.74	.711	.661	.638	.617	.528
38.....	1.187	.905	.826	.792	.76	.731	.678	.655	.633	.543
39.....	1.219	.928	.848	.812	.78	.750	.696	.672	.650	.557
40.....	1.250	.952	.869	.833	.80	.769	.714	.689	.667	.571
41.....	1.281	.976	.891	.854	.82	.788	.732	.707	.683	.586
42.....	1.312	1.000	.913	.875	.84	.808	.750	.724	.700	.600
43.....	1.344	1.024	.935	.896	.86	.827	.768	.741	.717	.614
44.....	1.375	1.048	.956	.917	.88	.846	.786	.759	.733	.628
45.....	1.406	1.071	.978	.937	.90	.865	.804	.776	.750	.643
46.....	1.437	1.095	1.000	.958	.92	.884	.821	.793	.767	.657
47.....	1.469	1.119	1.022	.979	.94	.904	.839	.810	.783	.671
48.....	1.500	1.143	1.043	1.000	.96	.923	.857	.827	.800	.686
49.....	1.531	1.167	1.065	1.021	.98	.942	.875	.845	.817	.700
50.....	1.562	1.190	1.087	1.042	1.00	.961	.893	.862	.833	.714
51.....	1.594	1.214	1.109	1.062	1.02	.981	.911	.879	.850	.728
52.....	1.625	1.238	1.130	1.083	1.04	1.000	.928	.896	.867	.743
53.....	1.656	1.262	1.152	1.104	1.06	1.019	.946	.913	.883	.757
54.....	1.687	1.286	1.174	1.125	1.08	1.038	.964	.931	.900	.771
55.....	1.719	1.309	1.196	1.146	1.10	1.058	.982	.948	.917	.786
56.....	1.750	1.333	1.217	1.167	1.12	1.077	1.000	.965	.933	.800
57.....	1.781	1.357	1.239	1.187	1.14	1.096	1.018	.983	.950	.814
58.....	1.812	1.381	1.261	1.208	1.16	1.115	1.036	1.000	.967	.828
59.....	1.844	1.405	1.283	1.229	1.18	1.134	1.054	1.017	.983	.843
60.....	1.875	1.428	1.304	1.250	1.20	1.154	1.071	1.034	1.000	.857

NOTE.—The above table and the one following are made to aid in determining the cost of a ration. If it is desired to ascertain the cost of a pound of oats when it sells for 23 cents per bushel, follow down the column under the heading "When a Bushel Costs" until the number 23 is reached; then to the right to the column headed "82," because there are 32 pounds in a bushel, where .719 is given as the price of 1 pound of oats. Multiplying this factor by the number of pounds of oats to be used in the ration gives 2.167 cents, the cost of 3 pounds of oats. If barley is fed, follow the line to the right until the column headed "48" is reached, which gives .479 as the cost of 1 pound of barley when a bushel costs 23 cents. If 4 pounds of barley are fed the cost is 1.916 cents.

TABLE CXXXIII.—Giving Cost of One Pound at a Given Price Per Ton.

Price of 1 Ton	Cost of 1 Lb.	Price of 1 Ton	Cost of 1 Lb.	Price of 1 Ton	Cost of 1 Lb.	Price of 1 Ton	Cost of 1 Lb.	Price of 1 Ton	Cost of 1 Lb.	Price of 1 Ton	Cost of 1 Lb.
\$	Cents	\$	Cents	\$	Cents	\$	Cents	\$	Cents	\$	Cents
.25	.0125	.57	.0285	.89	.0445	6.25	.3125	14.25	.712	22.25	1.112
.26	.0130	.58	.0290	.90	.0450	6.50	.3250	14.50	.725	22.50	1.125
.27	.0135	.59	.0295	.91	.0455	6.75	.3375	14.75	.737	22.75	1.137
.28	.0140	.60	.0300	.92	.0460	7.00	.3500	15.00	.750	23.00	1.150
.29	.0145	.61	.0305	.93	.0465	7.25	.3625	15.25	.762	23.25	1.162
.30	.0150	.62	.0310	.94	.0470	7.50	.3750	15.50	.775	23.50	1.175
.31	.0155	.63	.0315	.95	.0475	7.75	.3875	15.75	.787	23.75	1.187
.32	.0160	.64	.0320	.96	.0480	8.00	.4000	16.00	.800	24.00	1.200
.33	.0165	.65	.0325	.97	.0485	8.25	.4125	16.25	.812	24.25	1.212
.34	.0170	.66	.0330	.98	.0490	8.50	.4250	16.50	.825	24.50	1.225
.35	.0175	.67	.0335	.99	.0495	8.75	.4375	16.75	.837	24.75	1.237
.36	.0180	.68	.0340	1.00	.0500	9.00	.4500	17.00	.850	25.00	1.250
.37	.0185	.69	.0345	1.25	.0625	9.25	.4625	17.25	.862	25.25	1.262
.38	.0190	.70	.0350	1.50	.0750	9.50	.4750	17.50	.875	25.50	1.275
.39	.0195	.71	.0355	1.75	.0875	9.75	.4875	17.75	.887	25.75	1.287
.40	.0200	.72	.0360	2.00	1.000	10.00	.5000	18.00	.900	26.00	1.300
.41	.0205	.73	.0365	2.25	1.125	10.25	.5125	18.25	.912	26.25	1.312
.42	.0210	.74	.0370	2.50	1.250	10.50	.5250	18.50	.925	26.50	1.325
.43	.0215	.75	.0375	2.75	1.375	10.75	.5375	18.75	.937	26.75	1.337
.44	.0220	.76	.0380	3.00	1.500	11.00	.5500	19.00	.950	27.00	1.350
.45	.0225	.77	.0385	3.25	1.625	11.25	.5625	19.25	.962	27.25	1.362
.46	.0230	.78	.0390	3.50	1.750	11.50	.5750	19.50	.975	27.50	1.375
.47	.0235	.79	.0395	3.75	1.875	11.75	.5875	19.75	.987	27.75	1.387
.48	.0240	.80	.0400	4.00	2.000	12.00	.6000	20.00	1.000	28.00	1.400
.49	.0245	.81	.0405	4.25	2.125	12.25	.6125	20.25	1.012	28.25	1.412
.50	.0250	.82	.0410	4.50	2.250	12.50	.6250	20.50	1.025	28.50	1.425
.51	.0255	.83	.0415	4.75	2.375	12.75	.6375	20.75	1.037	28.75	1.437
.52	.0260	.84	.0420	5.00	2.500	13.00	.6500	21.00	1.050	29.00	1.450
.53	.0265	.85	.0425	5.25	2.625	13.25	.6625	21.25	1.062	29.25	1.462
.54	.0270	.86	.0430	5.50	2.750	13.50	.6750	21.50	1.075	29.50	1.475
.55	.0275	.87	.0435	5.75	2.875	13.75	.6875	21.75	1.087	29.75	1.487
.56	.0280	.88	.0440	6.00	3.000	14.00	.7000	22.00	1.100	30.00	1.500

HOW TO COMPOUND A RATION.

In compounding rations, several things should be taken into account. When hay is fed, the ration should contain concentrates and roughage in about equal weight, while it should contain about one and a half as much roughage when cured sorghum, stover, or corn fodder is used, because these contain about 40 per cent. water, while the different kinds of hay contain, in round numbers, about 12 per cent. When ensilage is fed the ration should contain from 20 to 40 pounds, and 5 to 8 pounds of hay. For dairy cows that are expected to do full work for a long lifetime, about half the dry matter should be provided in the roughage, and half in the concentrates; but if it is desired to work cows only a

short time in the dairy, and make them yield the maximum amount of product, then the ration may contain less roughage and more concentrates. When grain is used, it is desirable to have two or more kinds, because it makes the ration more palatable. Cost of the ration should, however, not be ignored in making the selection, and when a ration can be made with one kind of roughage and one or two kinds of grain or mill feed at a marked reduction in cost, variety should be waived, and the economical ration used, as the maximum yield can be approximately secured by feeding good fodder corn for roughage, and bran, linseed meal, and cotton seed meal for concentrates. Of these all cows are very fond, and will eat a full ration all winter without showing the slightest inclination to tire of them.

Some succulent food is desirable in a ration, but not absolutely necessary. The concentrates mentioned are sufficiently laxative to counteract the constipating properties in the roughage. The concentrates, as a rule, may be fed dry, and not necessarily in connection with the roughage. So routine in feeding may be adjusted to the convenience of the feeder, and twice a day will suffice, though strict regularity as to quantity and time should be observed. This applies to calves and young stock, as well as to mature animals. Scales in the cow barn are just as essential as a time piece in the pocket or a clock in the house. To shovel the food to a cow is as unbusinesslike as for a grocer to guess the amount he delivers to his customers.

A standard ration should contain 25 pounds of dry matter, and of digestible substances, 2.5 of a pound of protein, 12.5 of carbohydrates, and .4 of a pound of ether extract or fat, for a cow weighing 1,000 pounds in ordinary working condition. But practically cows should be fed according to their feeding and producing capacity, and not according to their weight. Good results have been obtained by feeding only 2.25 pounds of protein daily. and until more definite information is obtained on

this subject, this will be the basis of our calculations. It also appears that no injurious effects are produced by feeding more fat than is fixed by the standard, and that quite as satisfactory results are obtained when the ration contains three-quarters of a pound of this nutrient. But great care should be taken not to exceed the amount of carbohydrates mentioned.

In view of the fact that there is considerable variation in the composition of food stuffs, the exact amount of nutrients contained in any food is not known without resorting to a chemical analysis, and since this is not possible with the farmer, the ration may contain only approximately the amount of the different nutrients mentioned in this standard.

Assume that the available food stuffs are timothy hay, barley, corn, and oats, and that the hay sells for \$6 per ton, barley for 30 cents per bushel, corn 25 cents, oats 20 cents, and undertake to formulate a ration composed of these only, using 14 pounds of timothy, and 4 pounds each of the grains. Referring to table CXXXI., we find that 14 pounds of timothy provides 12.15 pounds of dry matter, and of digestible nutrients .39 of protein, 6.07 of carbohydrates, and .19 of fat; that 4 pounds of barley contains 3.56 pounds of dry matter, and of nutrients, .35 of protein, 2.62 of carbohydrates, and .06 of fat; that the 4 pounds of corn provides 3.56 of dry matter, .32 of protein, 2.66 of carbohydrates, and .17 of fat, and that 4 pounds of oats provides 3.56 of dry matter, .37 of protein, 1.89 of carbohydrates, and .17 of fat. Referring to table CXXXIII., giving cost of 1 pound at a given price per ton, it is found that when timothy is rated at \$6 per ton, 1 pound costs .3 of a cent; and multiplying the cost of one pound by the number of pounds used it is found that the cost of the 14 pounds of hay is 4.2 cents. Referring to table CXXXII., giving the cost of one pound at given price and weight per bushel, and following down the first column until the price quoted for a bushel of barley is

found, which is 30 cts., and following the line horizontally to the right until the column headed 48 pounds is reached,—their being 48 pounds of barley in a bushel,—it is found that a pound of barley costs .625 of a cent. Multiplying the cost of 1 pound by the number of pounds used, it is found that 4 pounds of barley costs 2.5 cts. A bushel of corn weighs 56 pounds, and again following down the first column until 25 is reached, the price of a bushel of corn, and then horizontally across until the column headed 56 is reached, it is found that 1 pound of corn costs .446 of a cent, and 4 pounds four times .446, or 1.78 cts. And in like manner it is found that when a bushel of oats weighing 32 pounds costs 20 cents, 1 pound costs .625 cents and 4 pounds costs 2.5 cents. Combining the data obtained gives the following formula :

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Timothy Hay.....	14	12.15	.39	6.07	.19	Cents 4.2
Barley.....	4	3.56	.35	2.62	.06	2.5
Corn.....	4	3.56	.32	2.66	.17	1.8
Oats.....	4	3.56	.37	1.89	.17	2.5
		22.83	1.43	13.24	.59	11.0

Many farmers would consider this ration as 'generous feeding and probably would permit cows during the day to browse in the cornstalks or let them have access to the straw-stack. Heavy as the ration is it provides only 1.43 pounds of protein, which is only enough to produce half a mess of milk, after deducting the amount needed for bodily maintenance. None of the food stuffs in the ration can be increased because the carbohydrates are already in excess of the amount needed, and a cow fed such a ration will increase in weight and shrink in milk. In order to provide the nutrients needed for milk production, it will be necessary to take out some of the farm grown grains and substitute some mill products

that will increase the protein and decrease the carbohydrates. The 4 pounds of barley and 4 pounds of oats will bring 5 cents in the market at the prices quoted, and exchanging them for bran, the money will buy 10 pounds. Formulating a ration with the timothy, corn and bran gives the following:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost.
			Pro.	C. H.	Fat	
Timothy Hay.....	14	12.15	.39	6.07	.19	Cents 4.2
Corn.....	4	3.56	.32	2.66	.17	1.8
Bran.....	10	8.85	1.29	4.01	.34	5.0
		24.56	2.00	12.74	.70	11.0

This ration provides all the food an ordinary cow can eat in one day, since it contains 24.56 of dry matter. It also contains all the carbohydrates and fat needed; but it is still lacking in protein, since there are only two pounds in the ration. If the corn is reduced to 2 pounds and the bran increased to 12 pounds the ration will contain only 2.05 of protein. If the corn is taken out and the bran increased to 14, the composition of the ration will be as follows:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Timothy Hay.....	14	12.15	.39	6.07	.19	Cents 4.2
Bran.....	14	12.39	1.80	6.21	.47	7.0
		24.54	2.19	12.28	.66	11.2

This ration is rather bulky. It furnishes the nutrients needed for light dairy work, being still short in protein for a large milker. The poor ration cost 11 cents; by exchanging the farm grown grains for bran and adding .2 of a cent to the cost, a ration has been made which will provide the cows ordinarily kept on farms with the nutrients needed for fair work in the dairy.

A ration containing a greater variety would be better relished and if more protein could be provided without considerable increase in cost, better results would be obtained. Cows are exceedingly fond of early-cut, well-cured straw, so by reducing the timothy hay to 12 pounds adding 4 pounds of oat straw and only 12 pounds of concentrates composed of 4 of corn, 5 of bran, 2 of linseed meal and 1 of cotton seed meal, the ration will be greatly improved.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost Cents
			Pro.	C.-H.	Fat	
Timothy Hay.....	12	10.42	.34	5.21	.17	3.6
Oat Straw.....	4	3.63	.05	1.54	.03	.2
Corn.....	4	3.56	.32	2.66	.17	1.8
Bran.....	5	4.42	.64	2.00	.17	2.5
Oil Meal.....	2	1.82	.58	.65	.14	2.2
Cotton Seed Meal.	1	.92	.37	.17	.12	1.2
		24.77	2.30	12.23	.80	11.5

By giving each cow two feeds of timothy hay per day and what straw she will take, for roughage; and for concentrates a mixture composed of 4 pounds of ground corn, 5 of bran, 2 of linseed meal and 1 of cotton seed meal, giving to each as much as she needs to maintain her flow of milk, a fairly well selected herd should yield on an average about 300 pounds of butter during the year. Cows comfortably housed, regularly fed and milked, provided with water at a temperature of 60°F, and not compelled to remain out more than an hour during cold weather, may be fed of this ration all they will take without any danger of increasing in weight.

If the hay to be fed is a mixture of timothy and clover, containing about an equal quantity of each, twenty pounds of hay may be used in the ration and the bran reduced to two pounds. This will slightly increase the cost of the ration but it also increases the digestible protein from 2.30 pounds to 2.49 pounds.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Timothy.....	10	8.68	.28	4.34	.14	Cents 3.00
Clover.....	10	8.47	.68	3.58	.17	2.50
Corn.....	4	8.56	.32	2.66	.17	1.80
Bran.....	2	1.77	.26	.80	.07	1.00
Gluten Meal.....	3	2.76	.77	1.30	.33	2.40
		25.24	2.31	12.68	.88	10.70

It should be borne in mind that while butter fat may not be the direct product of protein, this important nutrient is needed to provide the casein and albumen in the milk serum, which is the host of the butter globules, and if sufficient protein for this purpose is provided in the coarse food, no expensive concentrates will be needed in the ration to secure medium dairy work.

In case all the roughage is clover, the concentrates in the ration may be composed almost wholly of farm-grown grains as is shown by the following:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Clover Hay.....	15	12.70	1.02	5.37	.25	Cents 3.75
Barley.....	4	3.56	.35	2.62	.06	2.50
Corn.....	4	3.56	.32	2.66	.17	1.80
Oats.....	4	3.56	.37	1.89	.17	2.50
Cotton Seed Meal..	½	.46	.19	.08	.06	.60
		23.84	2.25	12.62	.71	11.15

The ration composed of clover and 4 pounds each of barley, corn and oats provides all the nutrients needed for a full flow of milk, except protein, which is 2.06, while it should not fall below 2.25 pounds. Since there are 12.54 pounds of carbohydrates in the ration, which is the maximum amount that 24 pounds of dry matter should have, the shortage in the protein must be made good by adding

some food which contains a very high per cent. of protein and a very low per cent. of carbohydrates. No concentrate fills the two requirements so well as does cotton seed meal. Adding half a pound of this food to the ration at the cost of only .6 of a cent perfects it in every essential point, though it would not supply the protein needed for a very large yield of rich milk. For such, one pound of cotton seed meal should be added, which would increase the dry matter to 24.30 pounds and the digestible substances to 2.43 pounds of protein, 12.71 of carbohydrates, and .71 of ether extract. Feeding clover hay in place of timothy makes it possible to provide a palatable and properly balanced ration from the food stuffs grown on the farm with the aid of only half a pound of cotton seed meal. A similar combination may be made when alsike clover is available, as will be seen from the following formula:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Alsike.....	14	12.64	1.18	5.95	.21	Cents 3.50
Barley.....	4	8.56	.35	2.62	.06	2.50
Corn.....	4	3.56	.32	2.66	.17	1.80
Oats.....	4	8.56	.37	1.89	.17	2.50
		23.32	2.22	13.12	.61	10.30

This ration contains practically the same amount of protein and a trifle more carbohydrates; but the excess of carbohydrates is in a measure corrected by the decrease in fat. It cost 1.2 cents less than the balanced ration containing timothy hay, and .85 of a cent less than the ration containing clover hay.

When alfalfa hay is provided for roughage, the question of economy may receive more consideration than was permissible in the formulæ preceding. Alfalfa has not only a high protein content, but it is low in carbohydrates as

well. In examining the cost of the four pounds of barley, corn, and oats, it will be seen that the four pounds of corn cost only 1.8 cents, while each of the other grains cost 2.5 cents. It was for this reason that barley and oats were eliminated from the ration containing timothy hay; but the corn could not be increased, because it would provide too much carbohydrates. With alfalfa, however, no such difficulty arises; and corn may be substituted for the other grains or used exclusively for concentrates. When the proper combination is made, animals may be fed all they will eat with the maximum returns, without danger of injury by overeating.

The following ration contains the minimum amount of roughage to grain:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Alfalfa.....	15	13.74	1.65	5.94	.18	Cents 3.75
Corn Meal.....	10	8.91	.79	6.67	.43	4.50
		22.65	2.44	12.61	.61	8.25

When this combination is made, great care must be exercised as to the quantity fed. Corn meal differs from other grain meals and concentrates, and should not be fed without being mixed with some other food that will lie more loosely in the stomach, because it becomes too sodden when fed alone. When corn meal is the sole concentrate, the roughage should be passed through a feed cutter and the meal mixed with it. The ration costs 3.25 cents less than the one containing timothy, and 2.9 cents less than the ration containing clover.

A safer and better ration is formed by chaffing the alfalfa hay and mixing with it about half in weight of corn meal. The bulky character of the mixture will prevent an animal from eating too much.

FOOD	Lbs.	Dry Matter	DIGESTIBLE.			Cost
			Pro.	C. H.	Fat	
Alfalfa.....	16	14.66	1.76	6.33	.19	Cents. 4.00
Corn Meal.....	8	7.31	.63	5.33	.34	3.60
		21.97	2.39	11.66	.53	7.60

Valuing the hay \$5 per ton and the corn at 25 cts. per bushel, the cost of the ration is 7.6 cents.

The prairie hay growing in the northwest has been thoroughly tested with dairy cows in practical feeding and digestion experiments. Its composition and digestibility depends upon the character of the land with reference to moisture. That grown on low, damp land is termed "prairie swale," and contains 2.6 per cent. digestible protein. That grown on medium low land, and being a mixture of that grown on higher and lower lands, contains 2.9 per cent. digestible protein, while that grown on upland contains 3 per cent. protein. In feeding early-cut, properly cured prairie hay, there is no loss in waste, as cows take it all; and on this account it is a most satisfactory food. In compounding rations containing prairie hay for roughage, little farm-grown grain can be used, because of the low protein content, unless the grain is supplemented by some mill products containing much protein.

When corn is relatively low in price, it is desirable to use as much as possible in the ration, and one composed as follows will be very satisfactory:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Prairie Hay.....	15	12.61	.43	6.22	.18	Cents 3.00
Corn	5	4.45	.39	3.33	.21	2.23
Bran	5	4.42	.64	2.00	.14	2.50
Oil Meal.....	2	1.82	.59	.65	.14	2.25
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		24.22	2.42	12.37	.79	11.18

This is a most excellent ration, since it provides the nutrients in the right proportion. Though there is nearly twice the amount of fat called for by the standard, we have as yet failed to notice any injurious effect from such excess.

If it is desired to feed barley, it may be substituted for corn. This will materially reduce the fat in the ration, as will be seen by the following:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Prairie Hay.....	15	12.61	.43	6.22	.18	Cents 3.00
Barley.....	5	4.45	.43	3.25	.08	3.12
Bran.....	5	4.42	.64	2.00	.17	2.50
Oil Meal.....	2	1.82	.59	.65	.14	2.25
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		24.22	2.46	12.32	.69	12.07

This ration is in every essential point similar to the one containing the corn, except that it is more expensive. Wheat, oats or rye could have been substituted with similar results. Oats contain less carbohydrates, but make this good by contributing more fat. If more than five pounds of grain are to be fed in the ration, the bran must be reduced, and a little more cotton seed meal added. Rations should be so adjusted that the dry matter will not be much over 24 pounds, the protein not below 2.25, and the carbohydrates not over 12.5 pounds. Of the grains, corn is the cheapest, and of the mill by-products, cotton seed meal is the cheapest; so if as much of these is used as possible without unbalancing the ration, it will be provided at the least cost. In some of the rations given, gluten meal might be substituted for the cotton seed meal and oil meal.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Prairie Hay.....	16	13.52	.46	6.64	.19	Cents 3.20
Corn.....	6	5.35	.47	4.00	.26	2.67
Bran.....	3	2.65	.39	1.20	.10	1.50
Cotton Seed Meal..	2	1.84	.74	.34	.24	2.40
Oil Meal.....	1	.91	.29	.33	.07	1.12
		24.27	2.35	12.51	.86	10.89

This is about as cheap a ration as can be made with hay and corn as a considerable portion of it. A cheaper one can be compounded with fodder corn for roughage. When this food stuff is provided from 15 to 25 pounds should be used.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Fodder Corn.....	20	11.56	.50	6.92	.24	Cents 2.00
Corn.....	4	3.56	.32	2.66	.17	1.80
Bran.....	5	4.42	.64	2.00	.17	2.50
Gluten Meal.....	3	2.76	.77	1.80	.83	2.40
		22.30	2.23	12.88	.91	8.70

This ration costs only 8.70 cents, and provides all the material needed for milk production.

If clover can be fed with fodder corn, bran may be omitted and this ration balanced with the oil meal and cotton seed meal, at a material reduction in cost:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Fodder Corn.....	15	8.67	.37	5.19	.18	Cents 1.50
Clover.....	10	8.47	.68	3.58	.17	2.50
Corn.....	4	3.56	.32	2.66	.17	1.80
Oil Meal.....	2	1.82	.58	.65	.14	2.25
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		23.44	2.32	12.25	.78	9.25

If roots are available, the ration should contain one part each of grain and roots, and by weight once and a half to twice as much fodder corn as grain. The composition will be as follows:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Fodder Corn.....	18	10.40	.45	6.22	.22	Cents 1.80
Bran.....	5	4.42	.64	2.00	.17	2.50
Corn.....	4	3.56	.32	2.66	.17	1.80
Gluten Meal.....	3	2.76	.77	1.30	.33	2.40
Mangels.....	12	1.09	.13	.65	.01	.90
		22.23	2.31	12.83	.90	9.40

It is not deemed best to use more than four pounds of corn in a ration when cows are fed to their full capacity and are expected to work a full lifetime in the dairy. When cows are required to take two pounds of roots and one and a half pounds of fodder corn for each pound of concentrates, all danger of overeating is done away with.

When they are doing medium dairy work, and grain can be exchanged for mill feed, the following ration will provide the nutrients needed at low cost:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Fodder Corn.....	20	11.56	.50	6.92	.24	Cents 2.00
Corn.....	2	1.78	.16	1.33	.08	.90
Bran.....	4	3.54	.52	1.60	.17	2.00
Shorts.....	4	3.56	.49	2.00	.15	2.00
Oil Meal.....	1	.91	.29	.33	.07	1.12
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		22.27	2.38	12.35	.83	9 22

Corn silage does not meet with the favor among dairy-men that it should; not that it will produce more dairy products from a given area of land, but because it is a convenient way of storing good food that is always in palat-

able form. Furthermore, it economizes labor and space, and is uniform in quality. It is a most excellent food in summer when pastures begin to fail. A sufficient quantity should be stored to provide feed for the winter months and from the 1st of July to the 1st of September.

When corn silage is to be fed with clover, the ration can be as follows:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Corn Silage.....	30	6.26	.27	3.39	.21	Cents 1.50
Clover.....	10	8.47	.68	3.58	.17	2.50
Barley.....	4	8.56	.35	2.62	.06	2.50
Corn.....	2	1.78	.16	1.33	.08	.90
Bran.....	4	3.54	.52	1.60	.14	2.00
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		24.53	2.35	12.69	.78	10.60

This combination will be found exceedingly satisfactory since the foods employed are greatly relished by cows, and they furnish all the nutrients needed in the right proportion at a low cost. By substituting corn for the barley bran may be omitted and cotton seed meal used, making a reduction in cost.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Corn Silage.....	30	6.26	.27	3.39	.21	Cents 1.50
Clover.....	10	8.47	.68	3.58	.17	2.50
Corn.....	6	5.35	.47	4.00	.26	2.70
Oil Meal.....	2	1.82	.58	.65	.14	2.25
Cotton Seed Meal..	1	.92	.37	.17	.12	1.20
		22.82	2.37	11.79	.90	10 15

When fodder corn is to be fed with the silage, more of the concentrates carrying a very high per cent. of protein must be used, if a considerable amount of farm grown grain is to be fed.

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Corn Silage.....	30	6.26	.27	3.39	.21	Cents 1.50
Fodder Corn.....	10	5.78	.25	3.46	.12	1.00
Barley.....	6	5.35	.52	3.93	.09	3.36
Bran.....	3	2.65	.39	1.20	.10	1.50
Cotton Seed Meal..	2	1.84	.74	.84	.24	2.40
Oil Meal.....	1	.91	.29	.33	.07	2.25
		22.79	2.46	12.65	.83	12 01

The roughage in the silage and clover ration provided .95 of a pound of protein, while the silage and fodder corn provide only .52 of a pound, which calls for more protein in the concentrates to be fed, and on that account increases its cost. It may be observed that all the rations containing clover or alfalfa are relatively cheap, though they are rated higher than they would generally sell for, showing that their feeding value is not fully appreciated. Corn, both for silage and for cured fodder, should be planted so thickly that no ears are formed, as close planting provides a greater amount of nutriment from a given area, and in more digestible form.

If any of the ordinary hays other than that from the clovers are to be fed in connection with the silage, the combination may be made like the following:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Corn Silage.....	30	6.26	.27	3.39	.21	Cents 1.50
Timothy.....	10	8.68	.28	4.34	.14	3.00
Barley.....	4	3.56	.35	2.62	.06	2.50
Bran.....	4	3.54	.52	1.60	.14	2.00
Cotton Seed Meal..	2	1.84	.74	.34	.24	2.40
Oil Meal.....	1	.91	.29	.33	.07	1.12
		24.79	2.45	12.62	.86	12.52

If it is desired to feed cows roughage only, a ration may be composed of earless fodder corn, early cut and well cured,

soy bean and cow pea hay cut in full bloom and well cured. The combination may be made as follows:

FOOD	Lbs.	Dry Matter	DIGESTIBLE			Cost
			Pro.	C. H.	Fat	
Fodder Corn.....	14	8.09	.35	4.84	.17	
Soy Bean	9	7.98	.97	3.48	.13	
Cow Pea.....	9	8.04	.97	3.47	.10	
		24.11	2.29	11.79	.40	

The food stuffs should be run through a machine that cuts and crushes, mixed in the proportions indicated and fed in three meals per day. Stock raised on coarse feed only will eat enough of this mixture to do light work in the dairy. Pea hay cut in bloom may be used in lieu of either or both the soy bean or cow pea hay.

It is not intended that the rations should be made up exactly as formulated. In most of them any other farm-grown grain may be substituted in place of the one given. The formulas are more especially intended to suggest the proportion of grain to roughage, mill products to grains, and total concentrates to roughage. Local prices of food stuffs must largely determine which shall be used. Oats have been almost ignored, because it seldom occurs that they are a cheap food, either threshed and ground or in sheaf. Stover, usually called "corn stalks," has also been left out because there is such an indefinite amount of waste in feeding that it is thought better to leave it for feeding steers and young things.

The aim has been to show that the essential point in feeding for milk production is to provide enough protein and not too much carbohydrates; that the money value of food for dairy cows depends upon its protein content; that the cost of the different foods is a material factor; and that the food stuffs should be in such condition that the maximum amount of the most essential nutrient is available.

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UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN No. 68.

SUB-EXPERIMENT FARMS.

JUNE, 1900.

1. EXPERIMENTS AT COTEAU FARM.
 2. REPORT OF PROGRESS OF WORK AT THE
NORTHWEST EXPERIMENT FARM.
 3. REPORT OF PROGRESS OF WORK AT THE
NORTHEAST EXPERIMENT FARM.
-

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SUB-STATION EXPERIMENTS.

INTRODUCTION.

In establishing experiment farms the legislature has recognized three natural divisions of the state based upon widely differing agricultural conditions.

The first and most important is the southern division, lying south of a line drawn from east to west across the state at St. Cloud, and constituting nearly one-half its entire area. The conditions of this southern division are practically the same as those at the experiment station at St. Anthony Park, and the extensive line of experiments there carried on are conclusive so far as this region is concerned, supplemented as they are by investigations at Cotcau Farm, where the conditions are the same as those of a comparatively small area,—the western tier of counties bordering on South Dakota south of the source of the Minnesota river. In this southern division of the state mixed farming is the rule. The prairie soils are mixed clay and sand, fertile, but not inexhaustible. The farmers are progressive and prosperous, making their money out of live stock and grain crops with fruits and vegetables as side industries. The result is present profits and increasing fertility of soil. Good buildings, groves, fences, roads and other permanent farm improvements are being rapidly developed, and the prairie has already been converted into a land of attractive homes.

The second division is Minnesota's part of the great Red River Valley, covering an area forty miles wide by two hundred and fifty miles long. The conditions here are peculiar. Since the river flows north and empties into Hudson Bay, its source thaws first, while the ice to the north blocks up the outlet. This makes the valley subject to spring floods. The soil is heavy, poorly drained, with fertility seemingly inexhaustible.

It was once attractive to bonanza farmers, but there are few men in that region who do not now admit the necessity of a radical change in method. How to institute a permanently successful system of farming in the valley is a leading question at this time; and if the University can, by its experiments at the Northwest Farm, suggest a course which will put agriculture on as successful a basis as that of the southern division it will deserve the thanks of the people who have made their homes in the valley and add immensely to the wealth of the state.

The third division of the state is the Pine Region, which occupies about two-fifths of its entire area, and was originally covered with forests of pine, tamarack, oak and other valuable timber. Here are extended areas of sandy soils, sandy loam, with a smaller area of boulder clay and fine soils of mixed sand and clay, and in the extensive tracts of poorly drained areas a very large amount of peaty soil. The lumbermen have cut over the forests of this region and much of the land has been thought unfit for agriculture. Until recently but little attention has been paid to it by incoming settlers. During the past few years, however, a sharp advance in prices of other lands in the state has drawn a strong tide of immigration to this forest region, and the advance guard of settlers is pushing toward the northern boundary. It now seems probable that the agricultural interests of the third division will prove more valuable than its immense mineral deposits, which have already revolutionized the iron industries of the world. The peculiar advantages of this region agriculturally are its water communication with the whole world, its immense supply of wood and peat fuel, and its forests, which will gradually grow again. Through its Northeast Experiment Farm at Grand Rapids, the experiment station is in touch with the development of the farming interests in this whole region, and it is believed will be able to extend valuable assistance in disposing of the unsolved problems that confront the new settlers who are endeavoring to make homes where ten years ago it was not believed that farming could be successfully carried on, and in helping to inaugurate a system of practical forest management.

From the fact that peculiar conditions exist in the western tier of counties in Southwestern Minnesota, it was thought ad-

visable by the Regents of the State University to institute a series of experiments in that region, which is more subject to drouths than the central and eastern portions of the state. It was believed that, while the important problem of how to meet drouths could best be studied where drouth periods are most common and longest continued, the results of the experiments would be of immense value to the rest of the state where drouths are less frequent and of shorter duration. Fortunately the home-stead of Supt. O. C. Gregg, of the Minnesota Farmers' Institute corps, lies in Lyon county on the elevated ridge known as Coteau Hills, a location especially favorable for conducting the contemplated experiments. Mr. Gregg, who was naturally deeply interested in the proposed investigations on account of his institute work, generously offered the Board of Regents the use of whatever land was needed for the experiments and the necessary tools and machinery, free of cost, leaving the state to provide only the labor necessary to conduct the experiments to a conclusion. From the beginning Mr. Gregg has given the Regents hearty and intelligent co-operation. Work was begun in 1894, under Mr. T. A. Hoverstad, who remained until appointed Superintendent of the Northwest Experiment Farm at Crookston. During this period land was prepared for wheat and other crops with a view of finding the methods best adapted to tillage to conserve soil moisture so as to secure the largest possible crop yields. This work was laid out by Prof. W. M. Hays, of the Experiment Station, and was continued by him, assisted by Mr. W. G. Smith until the latter was offered a responsible place with the Department of Agriculture in Washington,—a promotion earned by the excellent work done by him on Coteau Farm. Mr. W. C. Palmer succeeded Mr. Smith and is now superintending the Coteau Farm work. The results of this work as given in this bulletin have settled many important questions and are of immense interest and value. They cover accurate measurement of the soil moisture under different conditions and methods of cultivation, as well as different stages of cultivation and growth, confirming or overthrowing theories by accurate information along the lines of tillage, field management, and actual crop production. In the main the methods used in carrying out these experiments have secured increased

yields, and the results clearly show the lines along which the farmer may confidently work. Where experiments have not produced favorable results they are equally valuable. It is as important to show what methods should be avoided as to point out those which lead to success.

The experiments in soil moisture entered what was then practically a new field. Fortunately uniform plots of land were obtainable on Coteau Farm, and investigations in soil tillage have been carried on in plots of one-twentieth of an acre or more, and in all cases in duplicate or triplicate series to insure accuracy. The actual yield of the crops as well as the conditions of moisture and temperature of both soil and air, the soluble plant food in the soil, the rainfalls and other weather conditions, have been carefully recorded for three years. These experiments were made with the utmost care, and covered not only the effect of methods of tillage on the moisture supply for the growing crops, but the influence of certain crops and tillage on the reserve supply of moisture for succeeding crops, the relation of bacteria and other forms of animal and plant life to soil moisture and systems of tillage, the effect of manuring and cropping on the supply of soil moisture, and the effect of rotation and special crops on future productiveness. By the practical application of the information gained by these experiments, progress has been made in growing tame grasses and forage, the relative value of fodder corn as a midsummer food as compared with other crops has been demonstrated, clovers have been made to grow abundantly,—not only on old land, but on newly broken prairie,—and timothy has been successfully grown for both hay and pasture. What has been done on Coteau Farm can be economically and profitably done on other farms in that region by the same methods. The new brome grass (*Bromus inermis*) has proved a marked success, and is confidently recommended for meadows and pastures in that region,—probably the most unfavorable for tame grasses in Minnesota.

Next in importance to what has been accomplished in field crops is clear proof that forest and fruit trees which are not hardy when unprotected on the open prairie thrive wonderfully when sheltered by belts of entirely hardy trees, which are easily and quickly grown. Such a timber belt protection can be grown

on any prairie farm, even in the southwestern Coteaus, in five years, and in another five years there may be grown inside of the belt all the fruits that are hardy in other portions of Minnesota. The essential features of the method are (1) a shelter belt of cottonwoods and willows around the plantation, (2) a dense planting of a mixture of quick growing trees like poplars and willows with slower growing varieties, like ash and elm, (3) making the grove of ample width to give real shelter, and (4) cultivating so thoroughly for several years that the surface soil will always be a mellow dust blanket and the weeds will not take up the moisture the trees need when young. It is unfortunate that every farmer who lives on the prairies of Southwestern Minnesota cannot see this handsome grove on Coteau Farm, and from it gather courage to plant and grow such a shelter belt about his own home place.

These are some of the important results already reached through experiments described in detail in this bulletin. Other interesting experiments are in progress along similar lines, from which equally important and practical results are expected.

The report which follows covers only the results of the experimental work of 1894 to 1898 inclusive.

WILLIAM M. LIGGETT,
Director.

EXPERIMENTS AT COTEAU FARM.

W. M. HAYS AND WM. G. SMITH.

In 1894 the State Experiment Station inaugurated several lines of experiments on Coteau Farm, Supt. Gregg's homestead. Coteau Farm lies four miles west from the village of Lynd, Lyon county, on the Great Northern Railway. The name comes from the Coteau hills, a broad, undulating morainic ridge running to the northwestward and rising 300 to 400 feet above the surrounding but more level prairie country of Southwestern Minnesota.

The soils of this part of Minnesota range from clay loam to loam and sandy loam. They are rich in plant food, absorb the water of rainfall readily, and endure seasons of drouth remarkably well. They make very good use of stable manures or green manures and furnish a congenial home for soil bacteria. The one particular in which this portion of the state differs from other portions is in the frequency and the greater severity of drouth periods, and this experiment work was undertaken largely to study how to overcome the effects of drouth and to secure greater crop yields where rainfall is irregular.

IMPORTANT QUESTIONS TO BE SOLVED.

Among the important questions deemed worthy of study, the following were especially considered:

(1) How to handle the furrow slice so as to store up and conserve the largest proportion of the frequently scant rainfall for the use of growing crops.

(2) To learn the amount of moisture each crop leaves in the soil for the succeeding crop, as a guide for arranging the order of the succession of crops in rotations.

(3) To learn the value of clovers, grasses and other forage crops for stock food, and for preparing the soil for succeeding crops.

(4) To discover the best means of increasing the supply of plant food and humus in the soil, whether by crops fed to domestic animals in barns or on pastures, by green manure crops, by leguminous crops, or by other means.

(5) To aid in the general experiments on how best to plan the farm and rotate and manage the crops.

(6) To learn the best methods of growing forest belts and their effect on field, garden and fruit crops growing under their protection.

In many ways Coteau Farm is especially adapted to the experiments undertaken in this, our drouthiest region. It is far to the southwest, and is elevated; the soil is only medium rich in plant food and humus, nearly resembling the typical soils in other prairie portions of the state as they will be when longer worn; it takes in moisture rather freely and gives it out slowly during a drouth. The soil of Coteau Farm is made up of the following mechanically separable constituents in the respective proportions shown in table CXXXIV.:

TABLE CXXXIV.—Mechanical Analysis of Average Upland Soil—Coteau Farm.

2-1 mm diameter of soil practices	(coarse sand)	4.0 %
1-5 " " " "	(sand)	.8 "
.5-.25 " " " "	(fine sand)	3.0 "
.25-.1 " " " "	(very fines'nd)	13.9 "
1-.05 " " " "	(" ")	7.7 "
.05-.005 " " " "	(silt)	34.9 "
.005-.0001 " " " "	(clay)	22.5 "
Organic matter, water, loss by ignition,		13.2 "
		100.0 "

This soil is only fairly dense or close grained, but is quite hard, is easily cultivated, and does not seriously bake if plowed when wet.

While Coteau Farm is somewhat isolated, the experiment work in progress there attracts numerous visitors. The fine young forest plantation protecting Supt. Gregg's buildings, stock, orchards and gardens has already served to demonstrate the value of a grove as a protection to garden and fruit plantations, as well as a shelter to the home, the barns and live stock.

FIELD MANAGEMENT.

As a part of experiments in field management centered at University Farm, the Experiment Station began studies at Coteau Farm in 1894, the special object being to learn how to increase the average yields of crops on the rich soils in South-western Minnesota which are sometimes subject to prolonged drouths. These experiments have been valuable in direct results, in paving the way to experiments in the rotation of crops and in methods of field cultivation at the several experiment farms.

The work first undertaken at Coteau Farm deals largely with conserving moisture in the soil.

In order that the discussions and diagrams of experiment work may be more clearly understood, a brief discussion of the movements and uses of water in the soil are here given.

SOIL WATER AND THE PLANT:

The plant gets its food supply through the water in the plant, which it drinks in or absorbs from the soil through the membranous surfaces of the roots with their root hairs, which latter greatly increase the surface connection of the plant with the water of the soil. Large quantities of water thus taken in by the plants are "breathed out" into the air through its leaves. The quantity of water thus taken in and given out by the plant is enormous,—field crops consuming two hundred to five hundred pounds of water for each pound of dry matter they add to their own weight in growing.

The roots of our field crops are much longer, much more numerous, spread farther and penetrate into the soil to greater depths than most people realize. On the fairly open, easily penetrable soils of this region, where the upper portion of the earth is often too dry for the plant to feed, crops send their deepest roots downward four to six feet and in some cases much deeper. The greater number of roots, however, are in the upper eighteen inches of earth. The richest portion of the soil, and the part in which the plant likes best to feed if sufficient water is present, is the lower half or two-thirds of the furrow slice. With

greater depth the plant obtains food with more difficulty. While the deepest roots doubtless secure some food, their chief function is to bring water from deep in the earth when the supply near the surface is short. These long, deeply penetrating roots have few branches near the tip, while the branches are very numerous near the surface, where the roots spread out so as to reach the more concentrated plant food from every nook and corner of the furrow slice and the uppermost layer of subsoil.

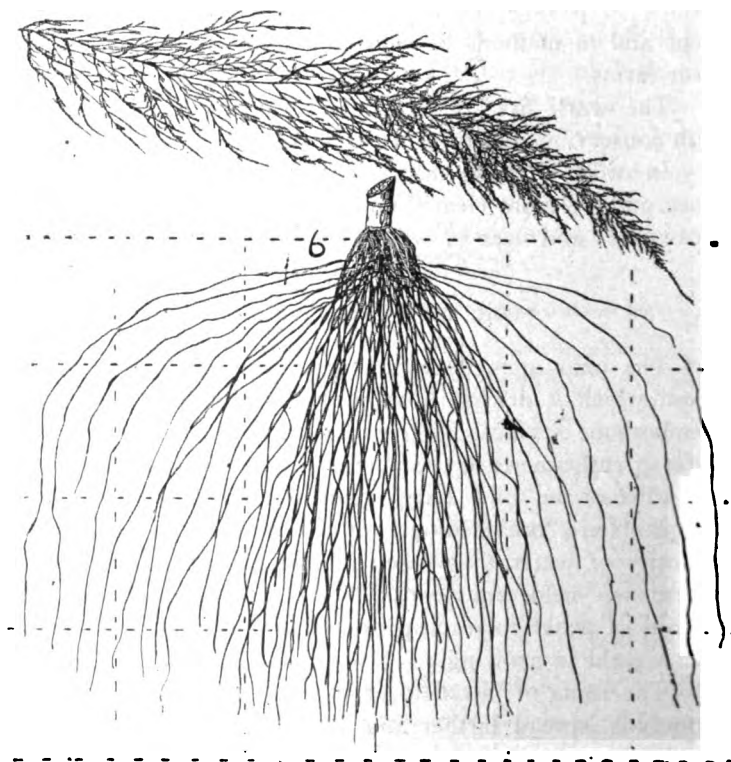


Fig.—250. At 6 are shown the stem roots of a corn plant nearly ready to tassel out. These roots all have their origin in the base of the stem, and each one has many branches as shown at x. The dotted lines mark off square feet. The largest roots penetrated nearly four feet downward while the spread horizontally including the branches, not shown in 6, was over six feet. This drawing was made from a plant nearly every stem root of which was dug out by means of a small wooden trowel, the length, depth and direction of the root being accurately recorded on the drawing.

In Fig. 250 is shown the root system of a corn plant ready to tassel. The branch roots are not represented. They are so

numerous that it is impossible to show all of them in the diagram. The roots shown are the mere framework of roots, their branches and sub-branches being very much more numerous, as shown at x, where the branches of one of the roots arising from the stem are shown. Only the outer, recently developed ends are active in absorbing water and receiving soluble plant food, the older surfaces being covered with a tough layer of bark-like cells.

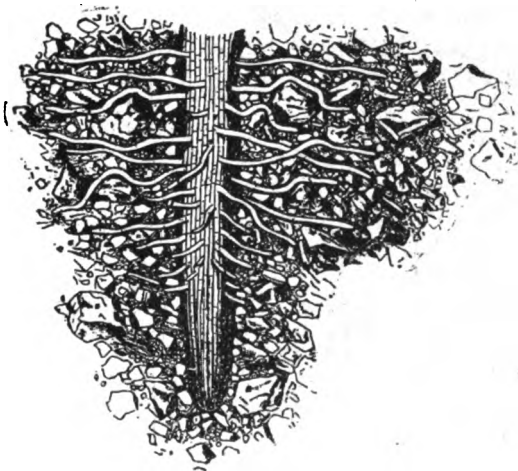


Fig. 251—Shows the outer end of a growing root, not of corn but of another plant (*Plisetum*), prepared by Dr. Otto Lügner for a previous bulletin. The fresh surface cells at the outer end of the point have not yet sent out root hairs. Those hairs nearest the tip are yet short, while those further back are more fully developed, and still further up on the root the hairs are found to have passed their stage of activity and are shriveled. The active feeding zone of the stem roots and of all branch roots are the outer ends, where the surface cells and their projections, the root hairs, are thin walled and actively at work absorbing water and plant food from the soil. Here is shown the wonderfully intimate contact the plant has with the minute particles of the soil.

In like manner Fig. 252 shows the general spread of the roots of a wheat plant.

The roots of other cereal grains are quite similar to those of wheat, and the roots of our tame grasses penetrate to similar depths. The clovers go a little deeper, while some perennial field crops, like alfalfa, extend much deeper. But in all cases the plants get most of their food in the upper layers of soil. Since the furrow slice and the part of the subsoil just below it are the portions of the soil which supply the most congenial

and the richest pasturage to the roots of crops, the aim of the farmer should be to keep them supplied with the proper amount of moisture and to provide that mechanical condition which best promotes the growth and yield of the crops.

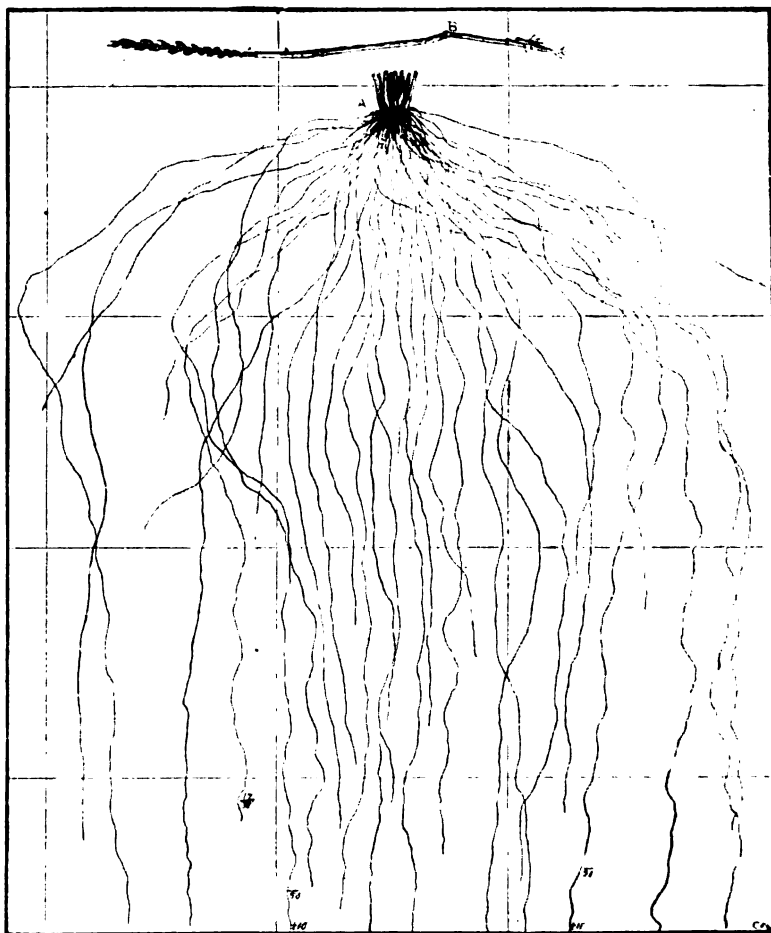


Fig. 252. Crown and stem roots of a mature wheat plant, from one seed. There are about 100 stem roots, each of which had for some distance on an average about eight branch roots to the inch, making a wonderful mat of roots in the soil. This plant stood alone and developed over a dozen culms. Numerous roots penetrated to the depth of four feet and the spread of the roots had a diameter of more than three feet.

FACTS ABOUT SOIL MOISTURE.

Since soil moisture conditions have seemed hard to control in Minnesota, the work to date has been directed more especially toward learning how to conduct moisture into the lower soil and conserve it there for the roots of the crops. That the relation of water and air to soil, to plant food, and to the roots of plants may be better understood, the following explanation is here presented. As an example, place a pot containing, say, one hundred pounds of water-free soil material in a hot oven until all the moisture has been dried out of it. See Fig. 253. The heat which was kept at the

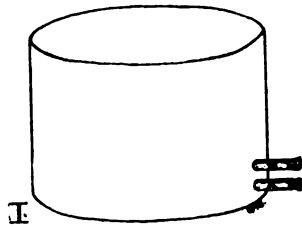


Fig. 253—Pot of 100 pounds of soil from which all water has been forced out by baking.

boiling point for water changed all the soil moisture into vapor and drove it off into the air. Now place this pot of soil in a room between open windows where the air can freely pass over it, but where no rainfall can strike it. Upon weighing the pot of soil some days later, we find that it weighs a few pounds more than when it was removed from the oven. See Fig. 254.

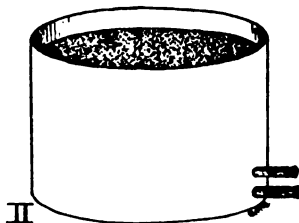


Fig. 254.—Pot of baked soil after standing several days in the air, when it weighs several pounds more from the absorption of hygroscopic moisture.

This increase is due to water the soil has absorbed from the air, just as quick lime or salt will absorb some of the water which exists as vapor in air. If we now close the room up tight and place several large kettles of water on a stove and cause them to boil vigorously the water will "boil away" and become invisible vapor in the air of the room. The soil in the pot will again increase in weight, as it absorbs more water from this very moist air than from the relatively dry air which had come through the windows. We will assume that the one hundred pounds of dry soil has absorbed three pounds of water when exposed for some days to the outside air, and that it was kept in the air made very moist and warm by the boiling water until it had absorbed two pounds more. For convenience we will call this the hygroscopic moisture of the soil. It gets this name from its having come from a vaporous condition in the air, where its amount could only be measured by means of an instrument called a hygroscope. This hygroscopic moisture enters into the very fiber of the soil particles, rather than attaching itself merely to their surfaces, as does the capillary moisture mentioned hereafter.

Now produce a miniature storm in the room by means of a fountain throwing a very fine spray on the surface of the soil in the pot. As the tiny raindrops strike they are eagerly seized by the small particles of soil. While the soil could not gather and condense more of the vapor of water from the air and associate it with its own particles, it at once shows a strong attraction for water in the liquid form. The water and the surfaces of the soil particles seem to desire the closest touch with each other, and as the water is a mobile fluid it spreads out in thin layers over the surfaces of the minute soil particles, enters into the pores within the particles, and fills the capillary spaces among them. If one particle has a thicker layer of water on its surface than its neighbors, the water is soon equalized over all. If in traveling from particle to particle the film of water finds a capillary pore or interstice, it fills it.

As the rain proceeds the particles at the top of the soil become surcharged with water. See Fig. 255. The water attracting power of the surfaces of the soil particles is satisfied, and they readily allow the layer of particles next beneath to draw

away the surplus. In this way a very gentle rain is taken hold of by the soil particles and slowly moved downward by what is termed the capillary force. The soil thus takes the moisture downward in much the same manner as a sponge placed with its lower portion in a small amount of water in a saucer will soon absorb the water into its own body. When the soil is filled or

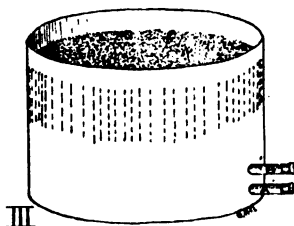


Fig. 255.—Pot of air dry soil after a very fine rain has been falling on it for some time. The capillary power of the soil has been satisfied nearly half way down through the mass.

saturated to its full capacity with capillary water, with its added water it weighs, say, 145 pounds. In Fig. 256 the soil is shown saturated in the upper half, and in the lower half ground water is standing, completely filling the interstices. Plants could not thrive in a soil as dry as that represented in Figs. 253 and 254, where only hygroscopic water was present, but crops which thrive in our arable lands have, through the centuries of their development, become accustomed to soils with their capillary forces only partly satisfied. Soil with its capillary forces fully satisfied would be so wet that corn and most other crops would not thrive so well as if it contained only twenty to thirty pounds of water to the hundred pounds of dry soil substance. The solution of plant food would be too dilute; "the plant soup would be too thin."

If the rainfall is continued, the soil having no more unsatisfied power the water will pass to the bottom of the pot, obeying the law of gravitation, and gradually rise among the particles of soil in the bottom of the pot until the ground or seepage water has filled all the openings in the soil, forcing the air out from among the soil particles. This water in entering the soil follows a vertical direction until it reaches the surface of the

ground water, which is seeping sidewise and running out of the spout, illustrating the action of a tile drain; the water percolating downward to the surface of the ground water, then seeping sidewise and running into drains through openings between the ends of the tiles which do not fit very closely together. In most of our prairie soils this seepage water sinks far downward till an impervious layer is reached where it forms the ground water shown by the level of water in wells. With the continuance of the rainfall if the spouts, A and B, be closed, the ground water will rise, completely filling the interspaces within the soil, as in Figs. 256 and 257. More rain will cause the water to stand

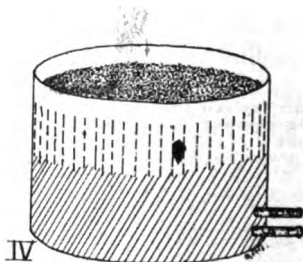


Fig. 256.—Pot of soil after rain has fallen on it until the capillary powers of all surfaces and interstices are satisfied, and the rainfall continuing ground water has filled the interstices between the particles of soil, displacing all the soil air in the lower half of the mass.

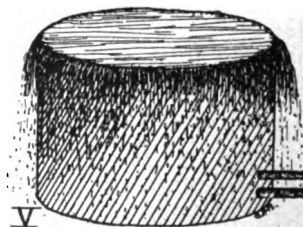


Fig. 257.—Pot of soil after rain has fallen on it until the soil is full of water, the rain continuing surface water has accumulated, filling the open space in the top of the pot and running off over the rim.

above the soil as surface water. If the spouts, A and B, be now opened, the surface water and the ground water will gradually drain out to the level of the drain. Figs. 258 and 259. The soil will still be very moist, but the drying action

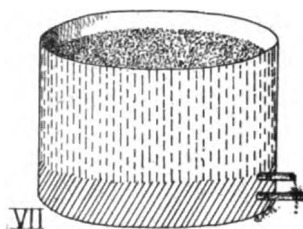


Fig. 258.—Pot of saturated soil after the drain at A has been opened and the ground water has been allowed to run out from all but the lower one-fourth of the soil.

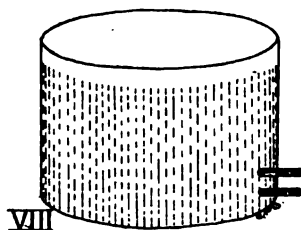


Fig. 259.—Pot of soil after drain, B, also has been opened and the remainder of the ground water drained out.

of the air will soon remove some of this excess by evaporating moisture from the surface particles. These in turn will be given some of the capillary moisture from the particles next below. Thus there will be a rise, an upward flow of moisture similar to the upward movement of oil in a lamp wick. If the ground water is sufficiently near the surface it will be a source of moisture, keeping the soil and subsoil partially saturated with capillary water and thus providing the crops with a constant supply of water. Thus in Fig. 258 the water in the bottom of the pot, not drained out because the drain at B remains closed, will be a permanent source of moisture to renew that taken up by evaporation from the surface of the soil into the air above, or that absorbed by plant roots growing throughout the upper portion of the soil. If this evaporation proceeds for a long time the soil becomes very dry. The air not only takes the moisture from the surface of the soil, but also the soil air in the interstices of the soil absorbs the films of capillary moisture from the surface of the soil particles. This watery vapor in the soil air

diffuses outward into the atmosphere above, aided somewhat by the slight circulation of atmosphere into and out of the soil.

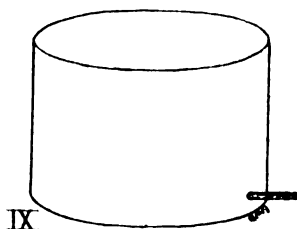


Fig. 260.—Pot of soil from which the capillary moisture has been dried out by exposing it for some weeks to the air, followed by several days of baking in an oven sufficiently hot to turn all moisture to steam and thus driving it out leave the soil dry of water, "water free," "dry substance," as when Pot I, Fig. 253, of baked soil was first placed in the air.

The soil filled with capillary water, as in Fig. 259, is gradually dried out again by the air so that only hygroscopic moisture remains. And if the pot is again placed in an oven which is kept at the boiling point of water the soil will be again reduced to the water-free state. Fig. 260.

Fig. 261 illustrates the fact that the capillary force carries water in any direction in the soil. A funnel tube carries the water to the center of the mass of earth very slowly. The particles immediately surrounding the point of the tube are sat-

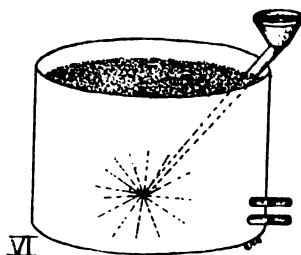


Fig. 261.—Pot of air dry soil, containing only hygroscopic water. Through the funnel tube water is slowly run into the center of the mass of soil. This water is carried away from the point of the tube in all directions by the force of capillarity. Gravity causes a slight tendency for more to go downward than in other directions. But capillarity being much the more powerful acting force under these conditions causes the water to go upward and sidewise as well as downward.

urated with the water. This water clings to the surface of the particles and spreads out in thin films. The attraction of the water for the neighboring particles causes these films to stream

outward towards the drier particles where the capillary forces are less satisfied. Thus the moisture moves upward and side-wise nearly as rapidly as downward, in which direction gravitation helps to move the water while retarding the flow over surfaces in other directions.

Our soils, instead of having this underground supply of water stored up to be given out gradually as used by the roots of crops or evaporated from the surface of the soil, are as a rule not very moist at a depth of several or many feet. The rain which falls upon the soil in part runs off over the surface, especially if it be hard or slanting, or both. That which is drawn in by the capillary force or sinks in by gravitation is taken up and held as capillary water. A light rain is carried downward to a slight depth only, while a heavier rain will go deeper. Several inches of rain falling at once or at close intervals is necessary to penetrate to the depth of several feet, partially satisfying the capillary force of the soil.

In case sufficient rain falls to penetrate to only a few inches the moist surface soil soon begins to give up its moisture in two directions. The moister particles give up their water to the drier soil beneath as was described above, and as soon as the sun warms and dries the air at the surface, moisture is evaporated and there is a movement of water toward the surface in the moist zone or layer of soil. These movements continue for a time, but soon the zone of moist soil will have given up sufficient water so that it is no more moist than the subsoil below, and the downward movement will cease. But, since the sun and wind are in almost daily action in summer in evaporating water from the surface of the soil, there is a movement of capillary moisture upward nearly all the time. Part of this moving mass of water is intercepted in its upward flow by plants which take it into their roots, pass it to the leaves and soon give it back to the atmosphere.

NORMAL AMOUNTS OF SOIL WATER.

WM. G. SMITH.

A study was begun to determine the amount of water which is best for plants. This varies in different soils. An upland soil was chosen, also a lowland soil partially made up of peat. Five pails were filled with each. Table CXXXIV. on page 563 gives the mechanical analysis of the upland soil. Instead of 13.02 per cent. of organic matter in the upland soil, the lowland soil contained 28.6 per cent.



Fig. 262.—Two pails of upland soil bearing the best flax plants and two pails of lowland soil bearing the best flax plants.

During the growth of the plants, the moisture in the different pails was maintained at different points. In upland soil the following percentages were maintained in the respective pails: 1st, 10; 2d, 20; 3d, 30; 4th, 40; 5th, 50. In the lowland soil the percentages of water to dry matter of soil ran as follows: 1st, 20; 2d, 40; 3d, 60; 4th, 80; 5th, 100. These percentages were maintained during the growth of the plant by frequently adding water through small glass tubes inserted in the soil.

Flax plants were grown in each pail, and photographs of the two pails with upland soil and the two with lowland soil having the strongest plants are shown in Fig 262. In case of the upland soil 30 per cent. gave more healthful conditions for the flax than any of the other percentages. In case of the lowland soil the soil having 100 per cent. of water gave the strongest flax. This is further illustrated in Fig. 263. In each case more water or less water caused stunting, or in extreme cases death to the flax plant.

The experiment shows that a wider range of moisture percentages for plant growth is possible in a soil highly charged with organic matter, in the case of the upland soil the best plant growth apparently taking place at from 25 to 35 per cent. of soil moisture, while in the lowland soil the range was from 70 to 100 per cent.

Organic matter increases the water holding capacity of the soil and widens the range between drouth and excessive water supply, either of which is injurious to plant life. The fact that organic matter increases the water holding capacity of the soil is clearly shown by all the soil moisture charts in the tillage experiments reported on subsequent pages wherein manure of every description has figured.

There is also another suggestion no less important than the preceding, and that is that the water held by the organic matter from the grasp of the growing crop may be useful to the bacterial life that forwards the decomposition of organic substances in the soil, and as the decomposition continues there may be a gradual liberation of moisture as the organic substances are more and more reduced; and this water may thus be useful to the growing crops.

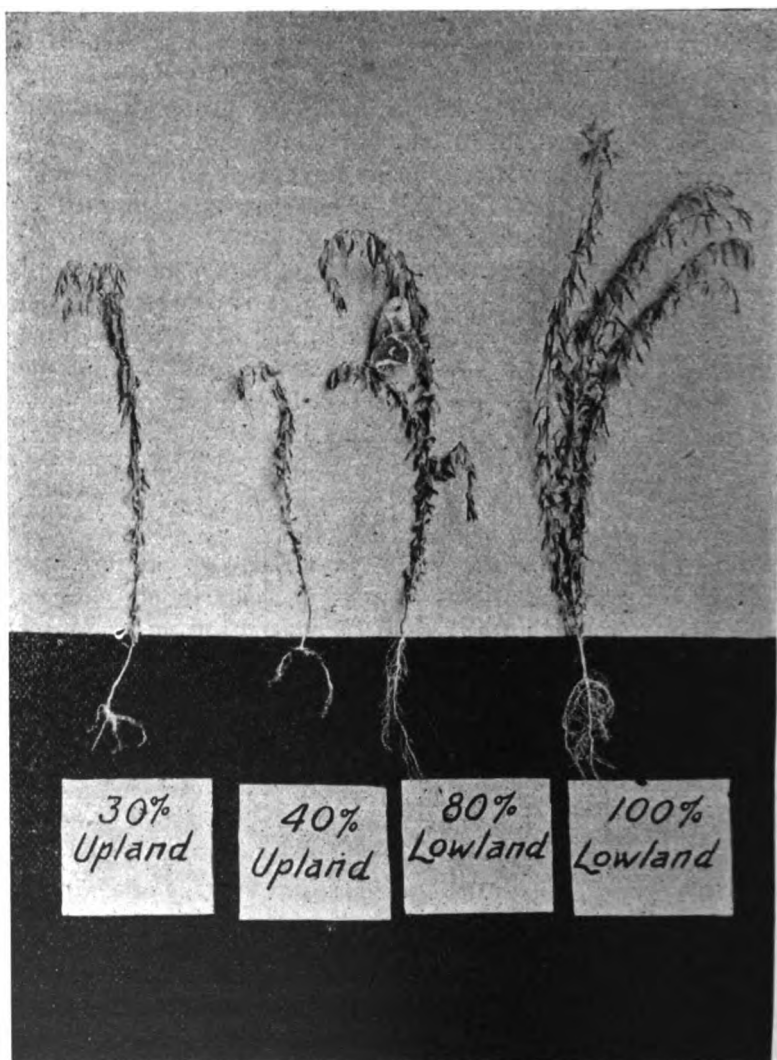


Fig. 263.—Selected plants from pails with percentages of water best suited to the growth of flax on upland and on lowland soils.

Bulk for bulk, the upland soil weighed about twice as much as the lowland soil. This brings the percentages given above, when expressed on the basis of the upland soil, down to 40

and 50 per cent. The thrifty growth of the plant which grew in the 100 per cent. of the lowland soil indicates that much more water could have been added without injury to the plant; also that the plant could have lived fairly well with less than 80 per cent. water. The results of this experiment are in perfect accord with the field tests figured in the soil moisture charts previously mentioned. Along these lines of soil moisture and soil fertility and the relations of the two much work should be done in the field and laboratory that we may have a scientific basis on which to build a system of crop rotations.

With the manner of handling the soil worked out with almost mathematical definiteness, application may be general and our field management reduced to a business basis. Giving the results in a sentence we have the following:

Organic matter associated closely with the soil increases its water holding capacity, and with more organic matter the range of the percentage of moisture congenial to the plant is widened; in other words, plant life will endure without injury more drouth and more excessive rainfall when a supply of organic matter is closely associated with the soil.

TILLAGE EXPERIMENTS AT COTEAU FARM.

W. M. HAYS AND WM. G. SMITH.

The tillage experiments begun at Coteau Farm in 1894 were reported in Bulletin No. 46 and in the Annual Report for 1895, pp. 384-389. These soil culture experiments dealing mainly with methods of treating the furrow slice have now been continued three years longer. The main features of the experiments and the objects sought have been much the same, but the methods of doing the work have been improved. Each year about 40 plots have been used in these experiments.



Fig. 268.—General view of Tillage Plots, Coteau Farm, 1898.

Plan of the Plots.—In Fig. 268 is shown a general view of the plots in one of the duplicate series of 1898, the same general arrangement having been retained throughout several years. The series are eight rods wide, and the plots running cross-wise are 20x132 feet in area. In each series there are plots

on which are grown crops of wheat, corn, annual pasture, and green manure, and other smaller plots used for studying soil moisture, which lie in fallow, one left bare and compact, another cultivated frequently, and still another on which a heavy mulch of straw is kept. The soil chosen was fairly uniform, and the duplicate results make averages which are very satisfactory.

The purpose of the investigation was to learn how best to secure large yields of wheat and other crops, and (1) how to so manage the furrow-slice as to get the greatest possible quantity of moisture into the soil (2) and to conserve it there for the use of the crop. Various methods of plowing, harrowing, subsurface packing and bare fallowing were compared, and the relations of annual pastures and green and stable manures to the soil moisture, as well as to the yields of crops, were studied. In most cases land was used which had borne wheat the previous year. By planting wheat for two or more years following the various treatments, the effect on future crops is being determined, and will be reported in future bulletins.

The results are expressed in two classes: (1) Crop yields and (2) soil moisture contents of the respective plots. The averages of the yields of grain and straw are all collected in Table CXXXVIII., and are again shown on many of the soil moisture charts, I.-XXVIII. The moisture percentages are expressed more clearly by means of curves in the charts. The chart method shows at a glance the relative effects of the respective treatments for each day and month of the season.

METHOD OF RECORDING THE RESULTS.

The wheat was harvested with a self-binder, threshed with a good separator, which was cleaned between plots, and the weights of the air-dried grain were accurately taken. The soil moisture observations alone represent some 4,000 tests for the two years here figured. The readings of 40 electrodes were easily made by one man in two hours each day with the new electrical device invented and perfected by Dr. Milton Whitney, Chief of the Division of Soils of the National Department of Agriculture. By the gravimetric method ten men would have been required to do this work, and the results would not have been so nicely comparable, or so accurate, as with this device.

The gravimetric method necessitates disturbing the soil at each determination of the moisture, while with the electrical method the soil is not disturbed after the electrode is once placed in it. This means that the moisture condition of the same portion of soil may be determined from day to day for the entire season without disturbing the soil at all. The moisture determinations are made with the soil particles always in the same physical adjustment about the electrode. The sources of error arising from weighing and handling small amounts of soil necessitated by the gravimetric method are eliminated by the electrical method. The principle on which the electrical method rests is that a wet soil conducts a current of electricity better than a drier soil. This is readily appreciated by those who know the need of having a lightning rod well connected with the moist soil beneath, else the rod will be a source of danger. An instrument known as a "soil rheostat," a modification of rheostats long used in physical laboratories for measuring electrical currents, was used to measure the variation of the electrical conductivity due to the variation of the amount of water in the soil.

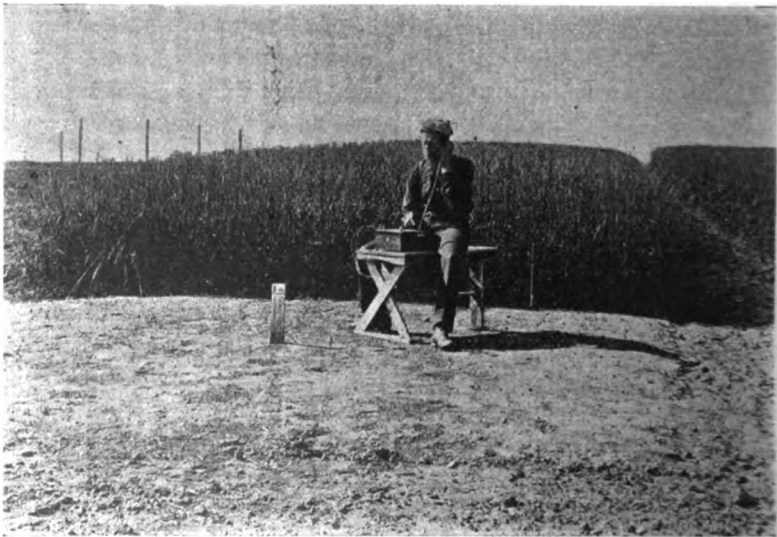


Fig. 269.—Taking soil moisture and soil temperature observations with Whitney's electrical device.

In Fig. 269 is shown the soil rheostat in use. The temperature of the soil is also determined with this machine. A glass tube containing a salt solution is placed in the soil at a desired depth. The ease with which a current of electricity may be passed through this solution varies with the temperature; the warmer the solution the more easily the current is conducted. Hence, by measuring this variation in the conductivity of the salt solution, the temperature of the soil in contact with the glass tube is readily and quickly determined. For further information on this valuable device, see Buls. 6-9, incl., of the Division of Soils, U. S. Dept. of Agr.

TABLE CXXXVIII.—Yield of Wheat In Tillage Plots for 1896, '97 and '98.

Treatments	1896			1897			1898		
	Wheat	Straw	Proportion wheat to straw	Wheat	Straw	Proportion wheat to straw	Wheat	Straw	Proportion wheat to straw
Spring plowing	7.9	1045	1-2.2	8.0	1586	1-3.0	26.8	3160	1-2.0
Sp. plow. and sub sur pk'ing	8.3	1522	1-3.0	9.1	1728	1-3.0	26.5	3000	1-2.0
Spr. plow rotted manure....	20.4	2186	1-1.8	17.3	2805	1-2.9	.....	.....	.....
Sp. plow coarsemanure	.....	.....	.....	.....	.....	.....	26.4	3000	1-1.8
Sp. plow coarsemanure and sub surface packed...	14.3	1580	1-1.8	14.3	2541	1-2.9	25.5	3080	1-2.0
Fall plowing	10.3	1270	1-2.0	7.8	1687	1-3.3	24.6	3300	1-2.2
Fall pl. and S. S. pack.....	10.5	1114	1-8.0	6.8	1635	1-3.7	25.6	3200	1-2.0
Fall pl. broad cast	8.7	1222	1-2.3	3.8	1452	1-6.6	.....	.....	.....
Fall pl. rotted manure	12.56	1457	1-1.9	10.8	2063	1-3.3	24.6	3000	1-2.2
Fall pl. coarse manure	16.43	2133	1-2.2	10.8	2645	1-4.3	26.4	3000	1-1.8
Fall plowing Drills 14 in. apart	9.2	1507	1-2.7	4.6	1715	1-6.3	.....	.....	.....
Fall plowing drills 21 in. apart	7.8	1242	1-2.8	4.1	1109	1-4.5	.....	.....	.....
Fall plowing	8.8	1292	1-2.4	8.0	1765	1-3.6	.....	.....	.....
Fall plowing Harrowed	.....	.....	.....	.....	.....	.....	.....	.....	.....
Org. grain Compact soil..	8.4	1219	1-2.4	7.7	1810	1-3.9	22.0	3840	1-3.3
Spring plowing 20 lbs lime added .....	.....	.....	.....	.....	.....	.....	23.0	2960	1-1.9
Spr. pl. S. S. pack .....	.....	.....	.....	11.92	2310	1-3.2	.....	.....	.....
Spr. plow. sub soiled subsurface packed...	.....	.....	.....	11.46	2503	1-3.6	.....	.....	.....
Spr. plowed	.....	.....	.....	11.23	2397	1-3.5	.....	.....	.....
Spr. plowed and Subsoiled	.....	.....	.....	11.00	2503	1-3.8	.....	.....	.....

Yields of Wheat Under Several Treatments.—In Table CXXXVIII. are collected, for convenience, the yields of wheat of the various plots planted to this cereal for each of the years 1896, 1897, and 1898. The figures for 1896 and 1897 represent the average yields of three plots in each case, and for 1898 the figures represent the averages of the two plots. In numerous tables these yields are used in the comparisons under the various problems. These same figures are also used in many of the charts. Several summaries are given in Table CXXXVIII., but these also are again given in connection with the discussion of the various problems.

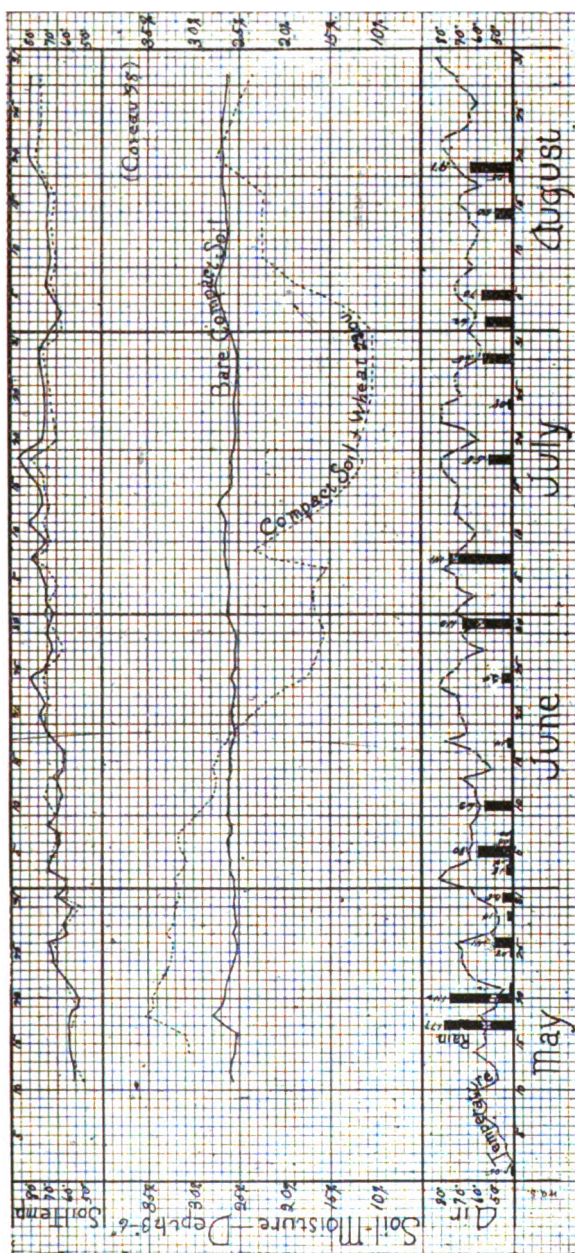
CROPS USE A LARGE QUANTITY OF WATER.

Careful experiments in America and in Europe have shown that one to two barrels of water (200 lbs. to 500 lbs.) are needed to produce a pound of the dry matter of many of our common field crops. If this amount is not available in the soil the crop suffers, and if the supply is irregular there is a lessened yield. In Western Manitoba every other season the land is kept in a bare fallow with the surface repeatedly stirred, that the moisture of two years may be utilized in producing a crop each alternate year.

The immense amount of water a crop draws up through its roots and allows to evaporate is clearly shown by Charts I. and II. The solid line moisture curve in each chart represents the moisture present in a plot from which the wheat stubble of the previous year was removed and the weeds kept from growing, no crop being planted and the soil not being disturbed for the entire season. The dotted line moisture curve represents the moisture present in another plot similarly treated, except that wheat was drilled into the hard surface. The object was to see how much the wheat would dry the soil.

Chart I. represents the moisture and temperature conditions on these two plots, as shown by electrodes at the depth of 3 to 6 inches, the lower half of the furrow slice, this land having been previously plowed.

CHART I. Wheat Crops Use Much Water from the Surface Soil.



NOTE.—Chart I. shows graphically the large amount of water a crop of wheat removes from the top soil during the crop growing period. In May, the surface soil in the plots planted to wheat had several percent, more moisture than the plots without a crop. As soon as the plants developed a large leaf surface they used much water, reducing the moisture nearly twenty per cent.; or down to only about ten per cent. when the crop was ripe, July 29th. The crop induced the soil to absorb more of the rainfall early in July, just as the forest enables the rain to percolate and not run off or be quickly evaporated as in the case of the bare land. The thirteen inches of rain which fell during the summer was sufficient to keep the bare soil as moist near the surface in summer as it was in May, while that bearing wheat became much drier. The crop shading the land prevented the soil from becoming so warm where wheat was grown as in the plot bare of vegetation.

Chart II. represents the moisture and temperature conditions at the depth of two feet on these same plots.

The wheat was harvested late in July, and a fair crop (22 bushels per acre) was secured from the plot planted to wheat. By inspecting Chart I. it will be observed that, while the occasional fall of rain was sufficient to keep the moisture in the bare plot up to what it was in June, in the plots bearing a crop of wheat the content of moisture ran down as the plants became large and leafy. It will be observed also that the content of moisture in the furrow-slice increased again as the crop was removed. In Chart II. likewise at a depth of two feet it will be seen that the deep going roots of the wheat were extracting large quantities of water from the soil.

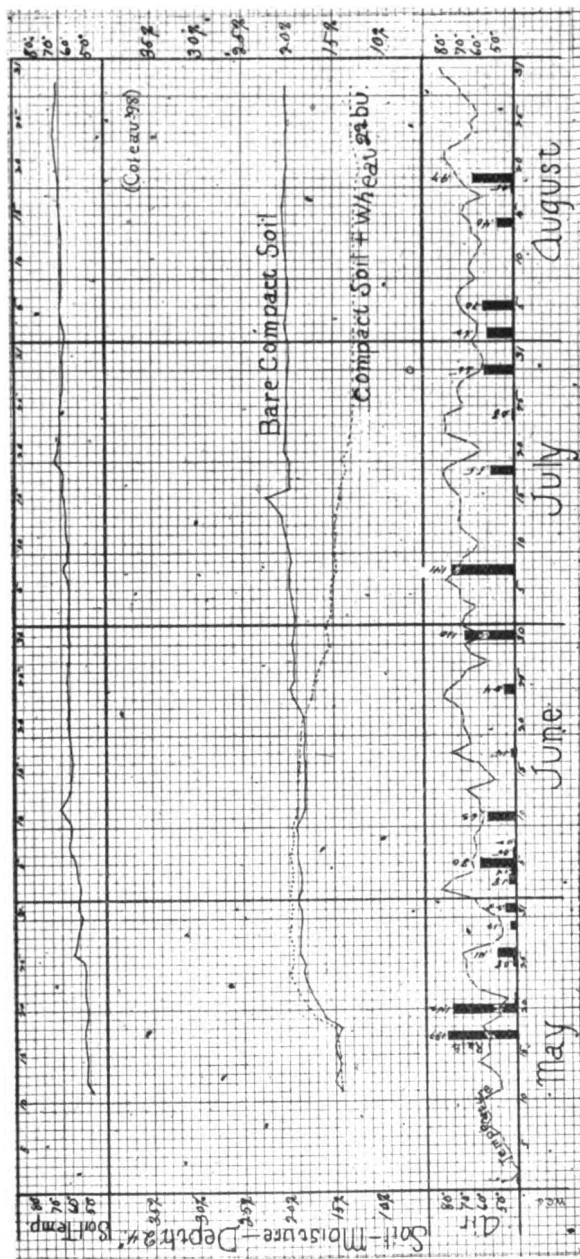
During the crop growing months of June and July when the foliage presents the greatest expanse of surface and the roots are reaching several feet into the soil for water, there is a very great draft of water manifest. A conservative estimate placed on the showing made in Charts I. and II. would place the average moisture percentage in the soil bearing a wheat crop fifteen per cent. below that in the soil bearing no crop. Using eighty pounds as the average weight of a cubic foot of this soil, we

NOTE.—Explanation of the soil moisture charts, I-XXVIII., inclusive.

The electrical method of recording the percentage of moisture has made it possible to show the movements of water into, through and out of the soil. Studying such data in long columns of tabulated figures would be most tedious and difficult. Since it is the relative variation in the moisture content of the same soil under different treatments that we desire to display here, a plain way of comparing the moisture in the respective plots is needed. With the invention of the electrical device making daily determinations possible came the need of a new method or a new language for expressing the data secured. It was found that some graphic method must be resorted to, and the following moisture charts are the result. These charts express the air temperature and the soil temperature, the rainfall and the soil moisture in a language not limited to English or any other speech, once the mechanical construction of one chart is studied until it is understood. The charts are all made on the same plan and usually show only two comparisons, so as to avoid the confusion that several curves on the same chart would give rise to. A few moments' inspection of any one chart will show that the vertical lines of the cross-section paper used mark the days of the month, while the horizontal lines mark the places for plotting the soil moisture and temperature observations. The lower portion of the chart shows the air temperature curve which is an average of the night and day temperatures. The rainfall is expressed in figures and in short vertical bars so that its relation to a change in the soil moisture curve may be easily noted. The middle portion of the charts explains itself on inspection. It shows the percentage of moisture in a given treatment as determined by the daily readings of the soil electrodes. The depth at which the observation was made is shown at the left hand of the chart. The upper portion also explains itself, showing the temperature of the soil at the same point that the moisture determinations were made.

The value of this method of expressing soil moisture observations over the tabular method will impress itself on any one who inspects one or two of the charts, since the conditions as they actually exist in the soil and air are here graphically shown. The effect of a small or large rainfall, the effect of periods of dryness, the effect of changes in the air temperatures, may be studied in connection with the variation of soil water and temperature. The relative variation of the moisture and temperature curve presents definitely to the eye the actual conditions.

CHART II. Wheat Crops Use Much Water from the Subsoil.



NOTE.—Chart II. represents the same plots as Chart I., but here the electrodes were two feet deep in the subsoil while there they were only 3-6 inches deep, or in the lower half of the furrow-slice. The four inches of rainfall in May penetrated deep, increasing the moisture four per cent. at two feet deep in the bare plot and five per cent. in the plot on which the young wheat plants were growing. As soon as the wheat plants were several inches high, with roots one or two feet long, the soil at two feet deep began to become drier, though the rainfall was 3.6 inches in June and 2.7 inches in July; and as shown by the solid line this moisture penetrated deeply and increased the amount of water in the subsoil in the plot bare of vegetation.

have a reduction of twelve pounds of water per cubic foot of soil caused by the crop; or about 523 tons (1,045,440 lbs.) per acre of water taken out of the upper two feet of soil by the crop. The total yield of dry matter of grain and straw was about two tons (4,000 lbs.). For each pound of dry matter produced the wheat drew up through its roots and gave to the air through its leaves 261 pounds of water. The 523 tons of water are equal to nearly five inches of rainfall. Prof. King found that a two ton crop of oat hay used water equivalent to about nine inches of rainfall.

Five to ten inches of rainfall are used by the crop during the crop growing months in the production of fifteen to twenty bushels of wheat or its equivalent of other crops. Since more than half of the annual rainfall is lost by drainage and by evaporation from the soil without passing through the plants of the crop, fifteen to twenty inches of rainfall are necessary to supply the required amount for good crops, and a large part of this is needed during the growing months. During a large part of the seasons the rainfall is not sufficient during longer or shorter periods of drought and our fields should be so managed as to increase the storage capacity of the soil. Crops which make but light drafts on the soil water should be used where practicable in preparing the soil for the next crop. Heretofore we have paid most attention to increasing the storage capacity of the soil by so treating the furrow-slice that it would take in the water of rainfall, and so that it would not allow the water to evaporate from the surface of the soil. Hereafter more attention will be given to learning how to so rotate the crops that those needing a moist soil will succeed crops which leave the larger supply to the following crop.

HOW WEEDS INJURE THE CORN CROP.

In 1898 corn was planted in drills in two plots in a similar manner, the plots being run in duplicate. On one plot the corn was cultivated thoroughly, no weeds being allowed to grow, and a loose mulch of earth every two or three inches deep was maintained throughout the early part of the summer. The other plot received but slight cultivation, the weeds being al-

lowed to grow freely until July 21st, when they were removed by hand and the soil was cultivated.

The corn grew strong on the well cultivated plot while on the weedy plot it did not thrive. Fig. 270 shows the relative



Fig. 270.—The well cultivated and the poorly cultivated plots of drilled corn on July 21, 1898.

development of the two plots just prior to removing the weeds from the poorly tended corn, and Fig. 271 shows their appearance three weeks later. The corn on the poorly cultivated soil made only slight recovery, and as shown in Table CXXXIX., p. 590, the yield per acre of corn and stover on this land was only slightly more than half of that produced on the well tilled soil.

A crop of 3,540 pounds of weeds reduced the corn crop from 12,762 pounds to 6,989 pounds, or 5,773 pounds. The weeds, which were mainly pigeon grass, were much more active in using water than was the corn. This fact is clearly shown in Chart III., p. 591, where it will be seen that the weedy crop reduced the moisture from the soil at 3-6 inches deep much more rapidly than did the corn on the well cultivated ground. This is doubtless due to the fact that the weeds developed very early, being nearly mature when removed on July 21. It is quite probable that these weeds use more water from the surface soil in producing a pound of dry matter than does the corn. Further experiments are being pursued to more clearly and forcibly

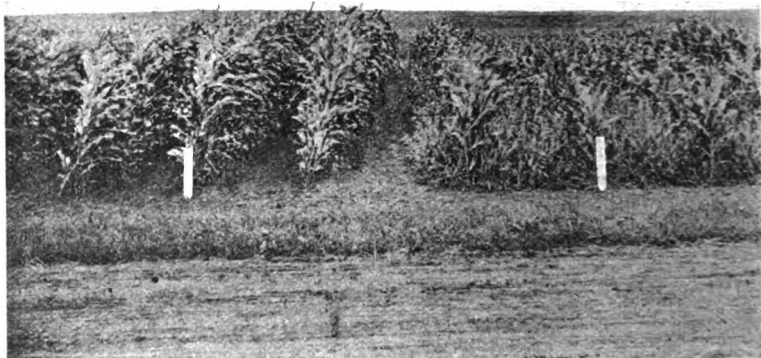


Fig. 271. The wellcultivated and the poorly cultivated plots of corn on August 11, two weeks after the weeds had been removed from the weedy plot and cultivation instituted there as well as on the other plot.

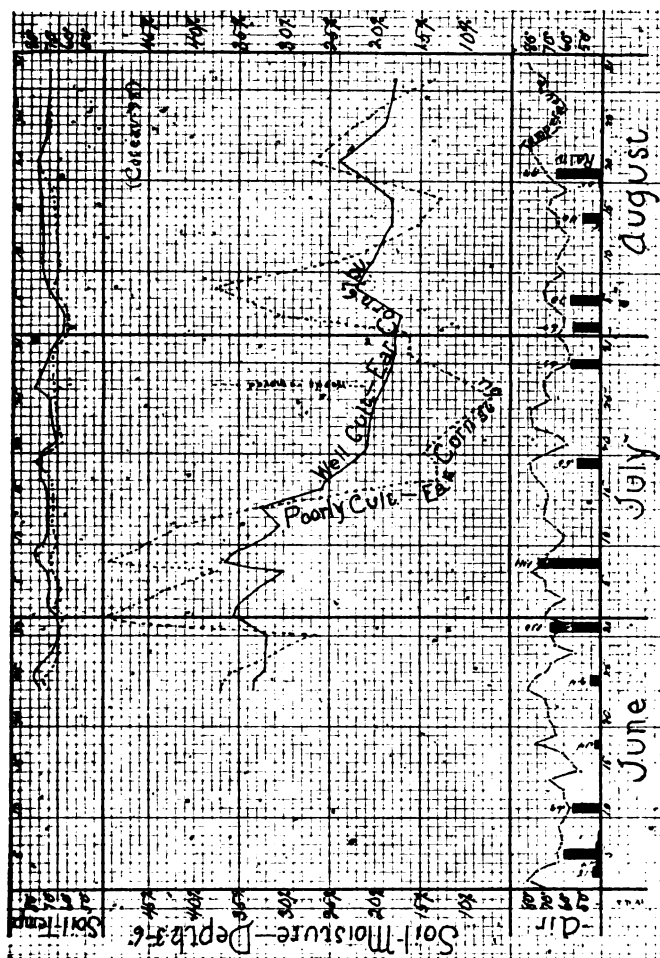
show the great loss of water and crop yields occasioned by weeds. Cultivated plants through long selection are adapted to produce the greatest possible amount of dry matter, protein, and value from the available plant food and soil moisture. Weeds are mongrel species which are very strong feeders, often more hardy in contesting for room and moisture in the soil and for sunlight than are the useful plants. They use a great amount of plant food and sunlight to make a comparatively small amount of dry matter, and that worthless or actually harmful in quality.

TABLE CXXXIX.—Poorly Cultivated vs. Well Cultivated Corn.

	Weeds	Ear Corn	Stover	Total lbs. per acre of crop and weeds.	Total yield of ear corn and stover per acre.
Corn—Well cultivated.....	.....	4824	6703	12762	12762
" Poorly cultivated.....	3540	2592	3653	10529	6989

Table CXXXIX. and Chart III. present some facts which our farmers should heed. More and better rotation and better tillage will greatly increase the yields and the quality of our crops.

CHART III. Weeds Among Corn Consume Much Moisture.



NORZ.—Chart III. shows that the well cultivated and weedy corn drew heavily on the moisture content of the soil at 3-6 inches deep. The poorly cultivated soil became moister after the early July rains than did the soil in the well cultivated area. But the weeds and corn combined made a much greater draft upon the moisture at 3 inches during the middle of July than did the corn alone on the well tended area. After the removal of the weeds on July 21st, the soil on the poorly cultivated plot became moister, showing that the stunted corn was not using nearly so much water as the heavier crop of corn on the well cultivated plot. The water-using capacity of the weeds was enormous. See pages 589-623.

Corn is a very sensitive plant. The average corn field in Southern Minnesota and in surrounding states does not produce over 70 per cent. of the crops which first-class farming would produce. The experiment emphasizes that one of the principal losses is caused by weeds, literally a "leak upward into the air of a large amount of soil water."

SUB-SURFACE PACKING THE SOIL FOR WHEAT IN
WESTERN MINNESOTA.

For several years the use of a sub-surface packer has been urged for the regions subject to droughts. This device has the combined action of a roller and a harrow. In appearance it is much like the wheel portion of a Havana or Hoosier press grain drill. The tires, instead of presenting a flat surface to the soil, are V-shaped, with apex outward. The theory of its advocates may be stated as follows: The lower half of the furrow slice needs to be packed and pressed down against the subsoil. The common roller compacts the surface only, pulverizes the surface soil, and gives the wind a better chance to drift the soil. Compacting the lower portion of the furrow slice by the sub-surface packer was supposed to restore its capillary connection with the moister subsoil, only the upper few inches of the furrow slice being used for a dust blanket. The zone, or layer of moist soil, is thus raised to nearer the surface, the moisture coming up to the mulch in fairly dry weather, instead of remaining at the top of the subsoil. This enables plants to obtain food in the lower part of the slice, whereas in soil which is open and often dry at the bottom, and sometimes disconnected from the subsoil moisture by a layer of loose stubble or barn litter, the plant must feed deeper down. Largely increased yields from sub-surface packed soil were confidently claimed, and it was determined to test the theory by careful experiment. Table CXXXVIII., p. 583, gives the results of numerous trials of the sub-surface packer on plots of wheat alongside of plots not sub-surface packed, both in spring-plowed and fall-plowed land; also on land where coarse manure had been plowed under. The figures for spring and fall plowed land in 1896 and 1897 represent the averages for triplicate plots and those for 1898 for duplicate plots.

The results are very uniform. In most cases there is a very slight increase in yield on the packed areas. This is well expressed in the grand averages at the foot of the table.

The sub-surface packer has not produced the decided results in raising the line of moisture in the soil in our drouthy climate nor in increasing the yields of wheat which had been claimed

for it. It does slightly increase the capillary activity of the lower part of the furrow-slice, as is shown by inspecting the moisture curves in Charts IV., p. 595; V., p. 598; VI., p. 602; X., p. 597; XVI., p. 599; XVIII., p. 596; XXI., p. 600, and XXIII., p. 601. The increased yield is too small to make the purchase and use of the machine profitable under these conditions. The seasons in which we have used this machine have been about average in the amount of rainfall and in its even distribution throughout the months when the crops are growing. In 1897, nine and seven-tenths inches of rain fell during May, June, July and August, and in 1898 ten and four-tenths inches fell during these same months.

At the ends of the fall-plowed plots bearing wheat crops small plots were kept bare of crops and electrodes were placed at 3-6 inches deep, that we might determine definitely whether sub-surface packing causes the lower part of the furrow-slice to be kept more moist when there is no crop to make a draft upon the soil water. By observing the moisture curves in Chart X., p. 597, it will be seen that the packer had little or no effect in increasing the moisture in the lower portion of the furrow-slice.

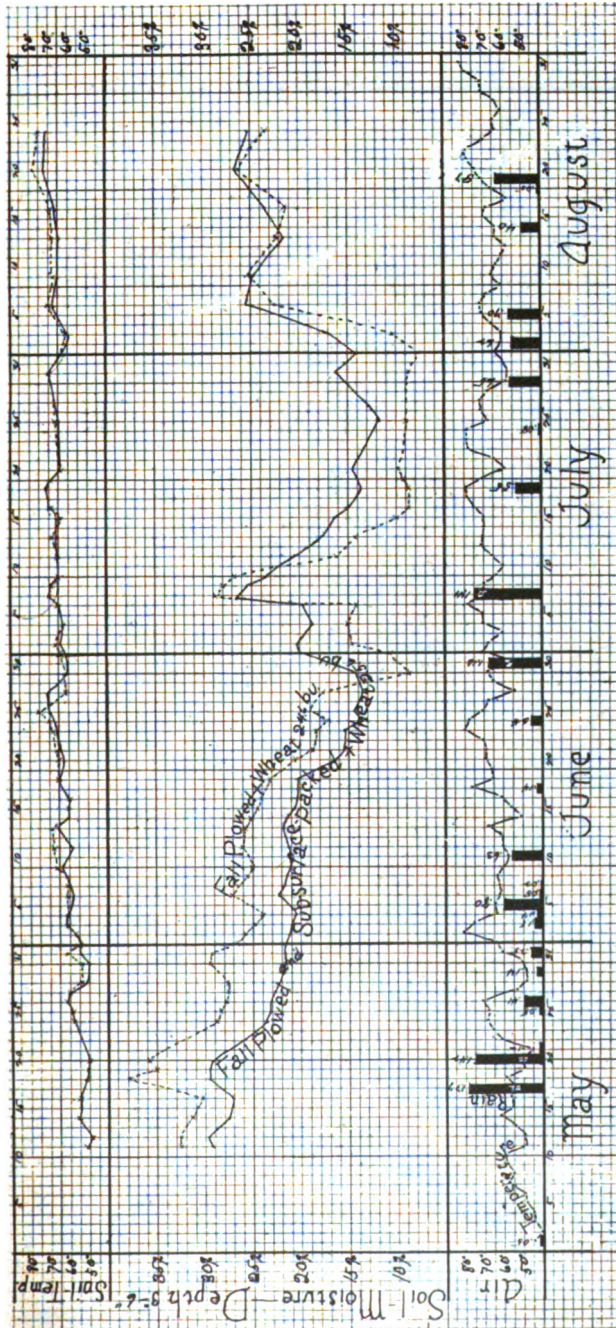
These plots were in duplicate and the results show very unfavorably for the sub-surface packer. Here all influences as crop, etc., were eliminated and yet the sub-surface packer had no influence in making the lower part of the furrow-slice more moist.

Coarse manure was plowed under in the spring of 1898, and part of the land was packed and part not packed. The results were against the sub-surface packer, though here it was expected to bring the greatest benefit. (See Table CXXXVIII., p. 583, and Chart VI., p. 602.)

The unpacked plot yielded a bushel per acre more than the packed plot. The soil at the depth of 3-6 inches did not become so dry in the packed as in the unpacked plot. Doubtless the larger crop on the unpacked land removed more water from the soil than was taken from the other by the smaller crop. After the crop was harvested, July 29th, the per cent. of moisture, as shown by the dotted moisture curve in Chart VI., p. 602,

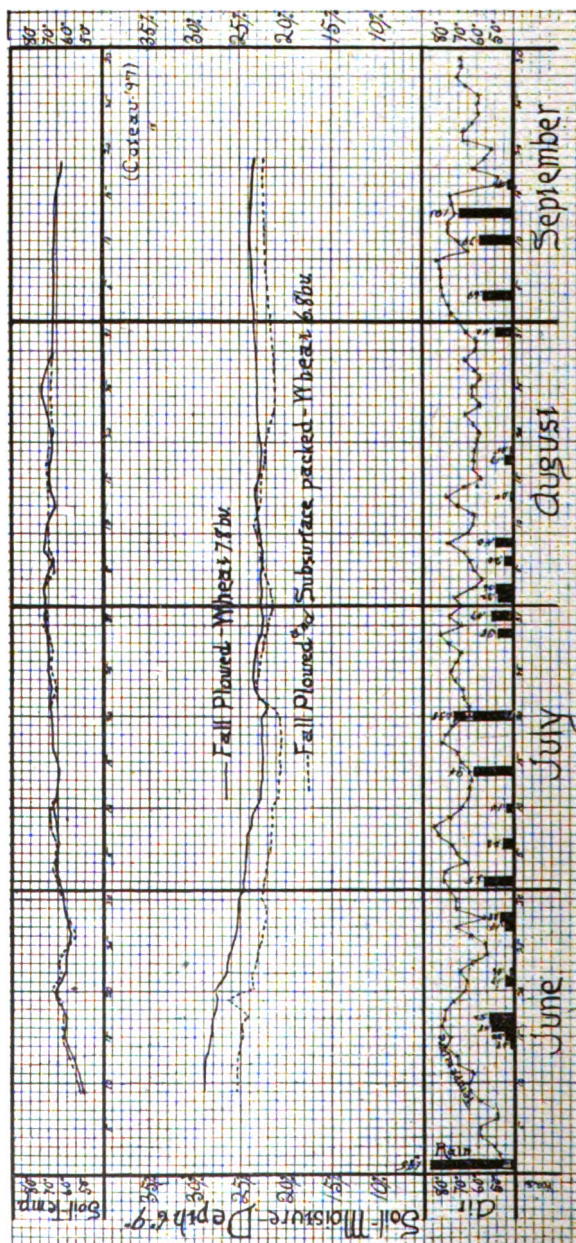
rose to equal that in the plot which had been packed. The sub-surface packer doubtless pressed the furrow-slice down more closely against the subsoil by compacting the soil and by pressing the layer of coarse manure into a thinner, more compact layer which would not so effectively cut off the capillary connections between the furrow-slice and the subsoil. This doubtless aids the rotting of the manure to a slight extent. It will be observed that late in the season after the crops were removed the moisture curve for the unpacked plot rises above that for the packed plot.

CHART IV.—Sub-surface Packing Fall-Plowed Land. Wheat.



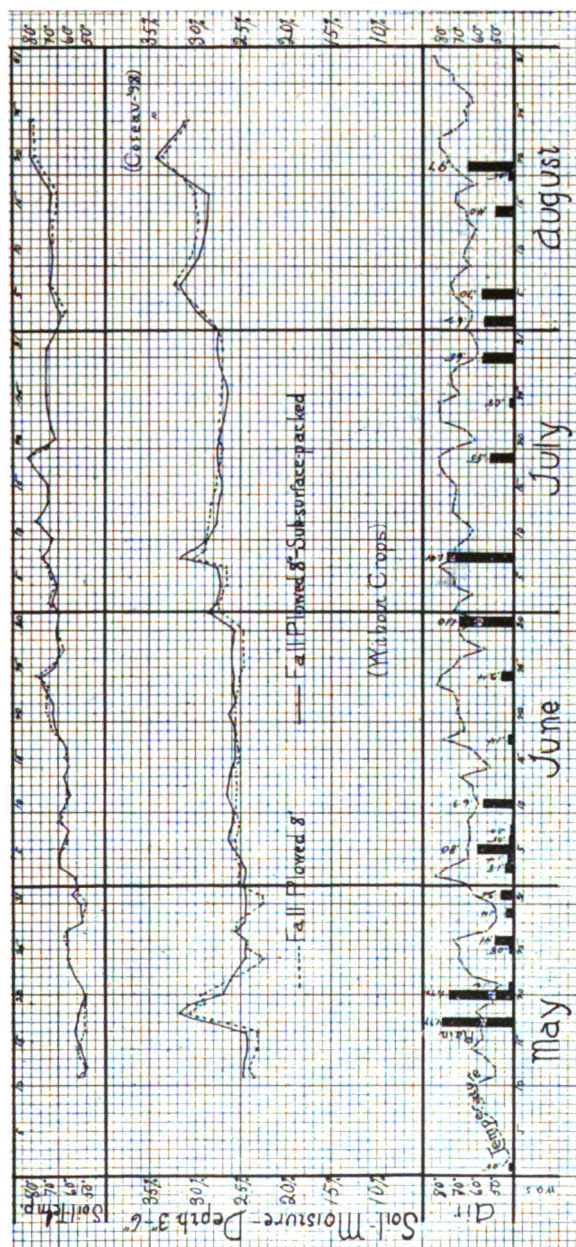
NOTE.—Chart IV. shows that early in the season of 1898 the plots of sub-surface packed fall-plowed land had less water in the lower part of the furrow-slice than those not packed, but later in the season the unpacked soil became the drier. In this case there was an increase of one bushel per acre of wheat over the unpacked soil. See page 593.

CHART XVIII. Sub-surface Packing Fall-Plowed Land.—Wheat.



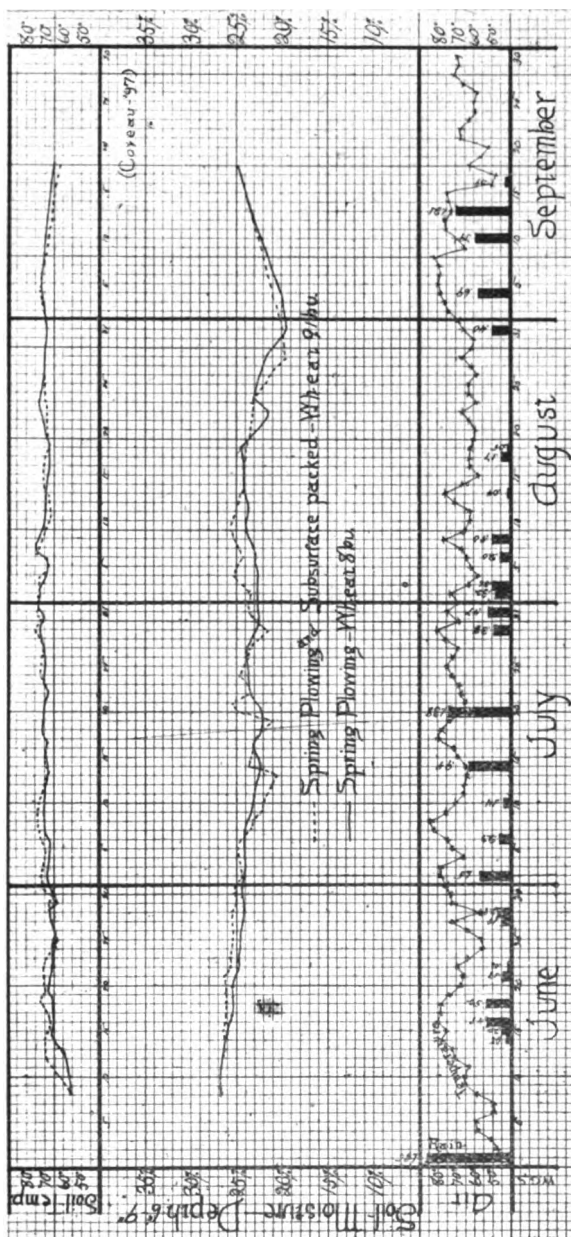
NOTE.—In chart XVIII. are shown the results of the treatment on the yield of the crop of wheat in 1897 and on the percentage of moisture at 6.9 inches by sub-surface packing the fall-plowed land in 1898. The packed soil yielded a bushel less than that not packed. The packed soil did not become so dry, but this was in part due to the less demand for water from the smaller crop. The temperatures of the soil remained about the same in the two plots. See page 598.

CHART X. Sub-surface Packing Fall-plowed Land—Without Crop.



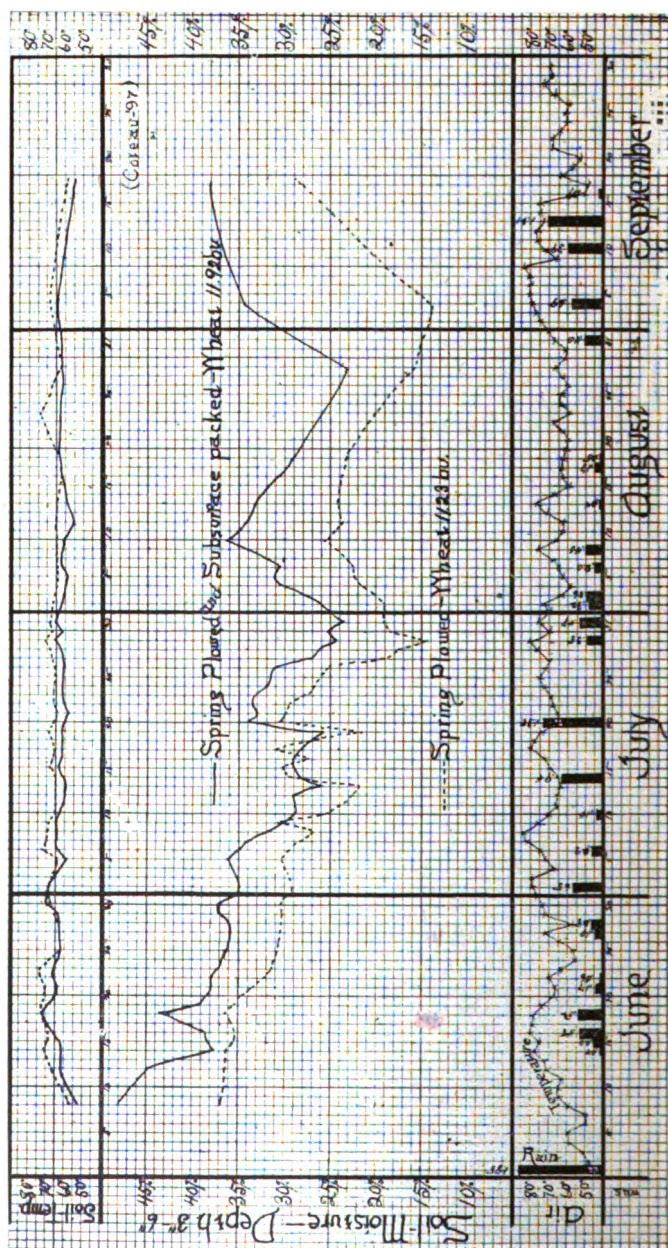
NOTE.—In Chart X, subsurface packing is compared with no packing on fall-plowed land bearing no crop. The soil moisture curves cross and recross, but keep very nearly together. There is a like increase of soil moisture in the two pairs of plots throughout the entire season. The temperature curves also run very close together. See page 593.

CHART XVI. —Sub-surface Packing Spring-plowed Land.—Wheat.



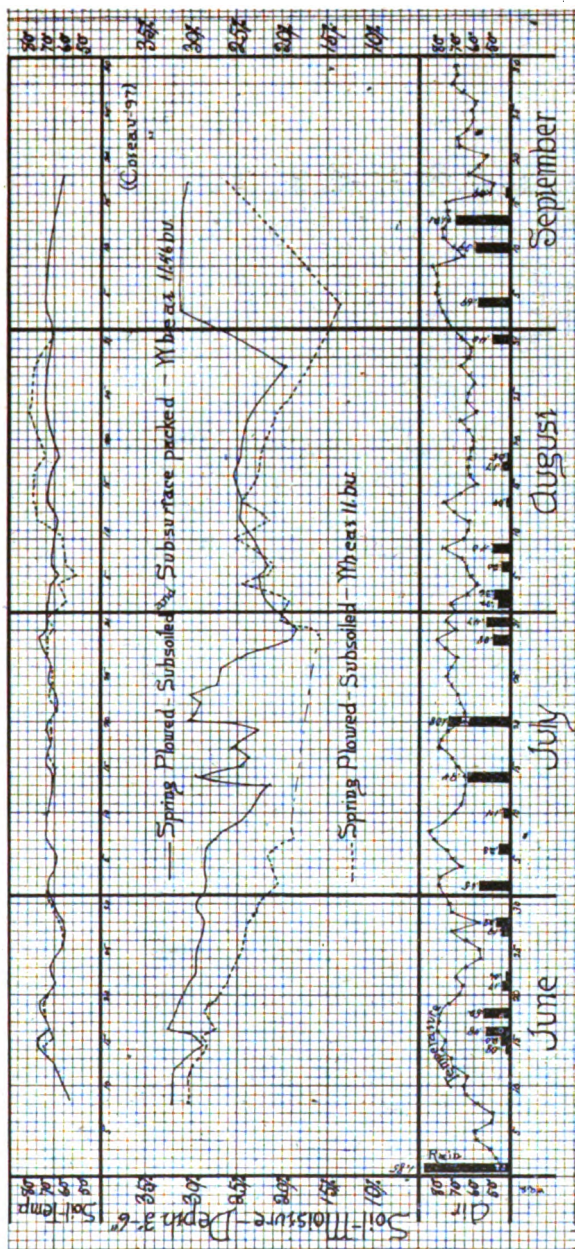
NOTE.—In Chart XVI, a comparison is shown for 1897 of spring-plowed land subsurface packed with spring-plowed land not subsurface packed. The electrodes were placed just below the furrow-slice at the depth of 6.9 inches. The packed plots yielded an average of one bushel per acre more of wheat than the unpacked plots. The packed soil seems to have conducted the water of rains down into the subsoil more rapidly than the soil not packed, as shown by the curve being more responsive to the rainfall. Before the crop was harvested the packed and unpacked soils were about equal in moisture. After the wheat was harvested, Aug. 2d, the packed soil became slightly the moister. See page 598.

CHART XXI.—Sub-surface Packing Spring-plowed Land.—Wheat.



NORM.—In chart XXI spring-plowed land sub-surface packed is compared with spring-plowed land not packed. The yield of wheat is seven-tenths of a bushel per acre more on the packed than on the unpacked soil, and there is several per cent. more of water at 8-6 inches deep. On the packed plot the loss of moisture was slightly greater up to the time of harvesting the wheat, Aug. 2d, owing in part to the larger crop. After the crop was removed the packed soil became considerably moister than that which was not packed. The packing evidently had the effect of decreasing the temperature of the soil, as shown by the temperature curve. See page 598.

CHART XXIII.—Sub-surface Packing Land Which Was Spring-plowed and Subsoiled.—Wheat.



NOTE.—In chart XXIII, the effects produced by sub-surface packing on land which had been spring-plowed and subsoiled in 1897 are shown. The land was plowed six inches deep and the subsoil plots were stirred seven inches deeper with the subsoiler. At the depth of 3-6 inches the temperature remained nearly the same on the two plots. Owing to an accident there is a break in the moisture curve for the most of July. There is an increase of over half a bushel of wheat per acre on the packed plots. The packing helped to overcome the bad effects of the subsoiling, as is shown by the larger percentage of moisture and larger crop yield in the packed plots. The packing made the capillary connection of the soil closer and more active in carrying the moisture into the soil, thus causing the electrodes to respond more quickly after rains. See page 593.

GENERAL SUMMARY.

(1) The subsurface packer has a slight effect on increasing the moisture in the lower part of the furrow-slice and on increasing the capillary activity in this part of the soil.

(2) The subsurface packer had little or no effect on modifying the amount of moisture in the subsoil immediately below the furrow-slice at the depth of 6-9 inches.

(3) Subsurface packing increased the yields of wheat only two-tenths of a bushel per acre, as averaged for ten plots with and ten plots without packing, and was not financially profitable under the conditions of this experiment.

(4) If subsurface packing is profitable anywhere it is probably under drouthy conditions and on loose ash-like soils. The packer leaves the soil ridged so that it will not drift so much before the wind as will soil which has been rolled with a common roller, and probably not so much as land which has been harrowed with the common spike harrow.

SUBSOILING FOR VARIOUS CROPS AT COTEAU FARM.

During the years 1896, 1897 and 1898 experiments were conducted to determine the influence of subsoiling on the yield of crops. Incidentally, moisture control work was carried along with a portion of the plot tests, that facts might be learned as to the effect subsoiling has on a supply of soil water to the crop.

SUBSOILING FOR CORN.

Table CXL., p. 604, gives results of subsoiling for corn in 1898 on spring-plowed and on fall-plowed-land. In each case the subsoiled plots were beside those not subsoiled and the comparisons were accurate throughout. In every case the subsoiling apparently reduced the crop of ears, also the crop of stover. The ear corn on the subsoiled plots was nineteen per cent. less in yield and the stover fifteen per cent. less.

TABLE CXL.—Subsoiling vs. Not Subsoiling for Corn.

	Ear Corn		Stover		Total Spring and Fall		Total Yield	
	Spring plow'd	Fall plow'd	Spring plow'd	Fall plow'd	Ear Corn	Stover	Of ear corn and stover	
Corn not subsoiled..	4179	5142	5477	5964	9321	11441	20762	pounds
Corn subsoiled.....	3549	4024	4459	5029	7578	9488	17061	"

SUBSOILING FOR WHEAT.

Table CXLI. gives the results of subsoiling for wheat in 1897 on spring-plowed land which had been sub-surface packed, both with and without subsurface packing. In each case there are lessened yields shown on the subsoiled plots.

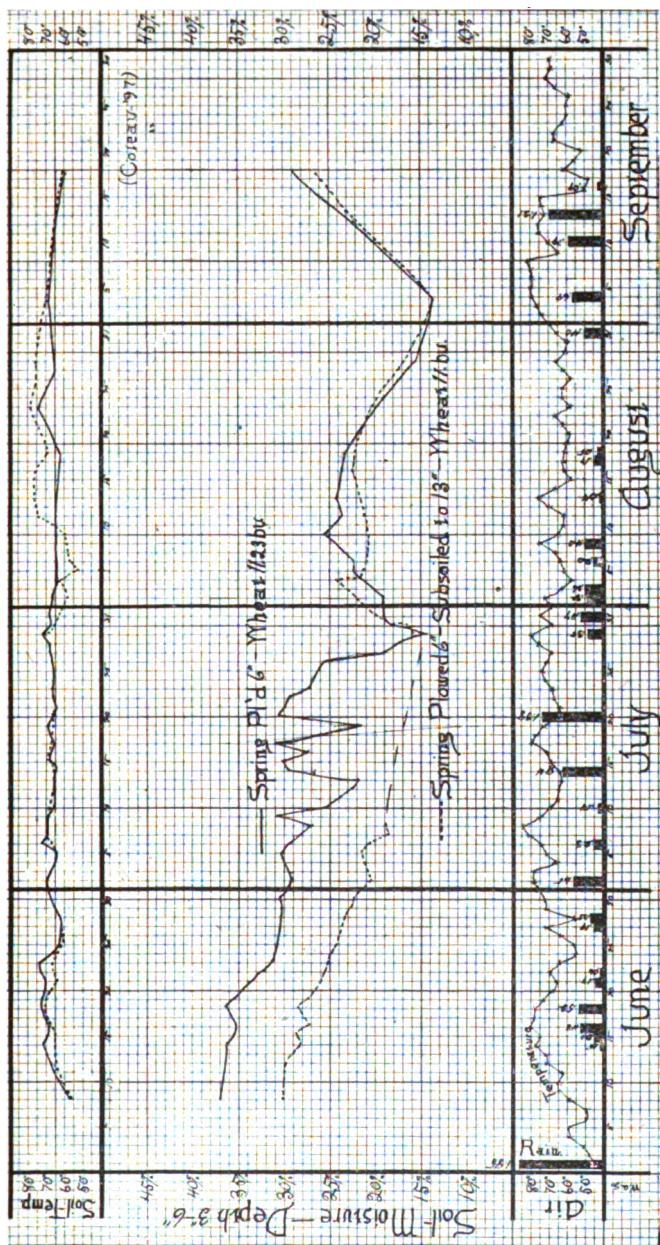
TABLE CXLI. Subsoiling vs Not Subsoiling for Wheat.

Treatments	Grain Bus.	Straw
Spring plowed and subsurface packed.....	11.92	2310
Spring plowed, subsurface packed and subsoiled.....	11.46	2503
Spring plowed.....	11.28	3397
Spring plowed and subsoiled.....	11.00	2508

SUBSOILING FOR SEVERAL CROPS.

Table CXLII., p. 606, gives the summarized results comparing subsoiling and not subsoiling under a variety of conditions and with several crops, and running through the three years 1896, 1897 and 1898. Out of the seventeen comparisons shown in these tables, fourteen show a decreased yield from subsoiling. In one case the yields are equal and in two cases there is a gain in favor of the subsoiled plots. The grand averages in these three tables show lessened yields of the subsoiled land in case of every crop tested. Not only did the wheat, oats and corn, commonly but erroneously termed surface feeding plants, yield less on the subsoiled land, but the potatoes, turnips and sugar beets also found this soil less suitable to their growth.

CHART XXII.—Subsoiling in the Spring for Wheat.



NOTE.—In chart XXII, the moisture curves show the moisture in the lower part of the subsoil, at the depth of 3-6 inches, in plots spring-plowed six inches deep and in plots spring-plowed to the same depth and subsoiled seven inches deeper. The data for part of July were accidentally lost. Early in the season the subsoiled plots had less moisture than those not subsoiled, but in August and September no difference was observed. The temperatures were about the same until the crop was harvested, but in August the subsoiled plots were several degrees warmer than those not subsoiled.

TABLE CXLII. Subsoiling vs. Not Subsoiling for Several Crops.

	1896		1897		1898		Grand Averages Spring and Fall
	Spring	Fall	Spring	Fall	Spring	Fall	
OATS	Subsoiled.....	17.5	11.5	.....	.....	.....	14.5
	Not subsoiled.....	18.0	15.6	.....	.....	.....	16.8
POTATOES	Subsoiled.....	.....	.....	99.5	111.3	148.7	124.2
	Not subsoiled.....	.....	.....	130.3	85.3	148.7	128.5
TURNIPS	Subsoiled.....	.....	.....	24698	30650	.....	27671
	Not subsoiled.....	.....	.....	26746	30190	.....	28468
FODDER CORN	Subsoiled.....	.....	.....	.....	4.7	.....	4.7
	Not subsoiled.....	.....	.....	.....	5.0	.....	5.0
WHEAT	Subsoiled.....	.....	.....	(See Table CXXXVIII, page 583.)		.....	11.2
	Not subsoiled.....	.....	.....	.....	.....	.....	11.6
SUGAR BEETS	Subsoiled.....	.....	.....	.....	9.3	14.7	12.0
	Not subsoiled.....	.....	.....	.....	10.1	18.1	14.1

Subsoiling is very expensive, and for nearly all our Minnesota conditions it will not pay in raising farm crops, if indeed in raising root or garden crops, or even young nursery trees under many conditions. It is easy to make most of our soils too open for the best growth of crops during our frequent periods of drouth.

Profs. Sheppert and Ten Eyck, at the North Dakota Experiment Station, Fargo, found that fall plowing and subsoiling eight inches deep increased the wheat crop but not sufficiently to pay for the cost of subsoiling. Where the subsoiler was run only 4-6 inches below the bottom of the furrow-slice they secured less yield of wheat than where the land was fall-plowed without subsoiling.

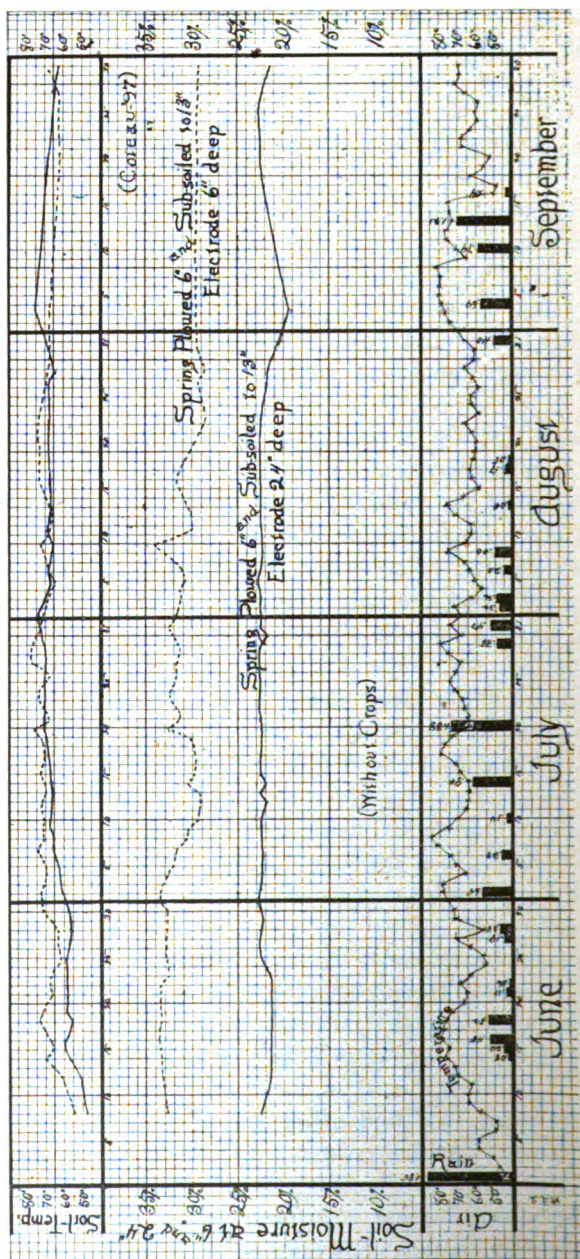
LOOSENING THE SOIL AND SUBSOIL AIDS RAIN TO PENETRATE DEEP.

It has been shown that loosening the surface of the soil catches portions of the rainfall which would otherwise run off over the surface. Deep plowing and subsoiling induce the water from a heavy rainfall to penetrate deeper into the soil. Chart II., p. 587, shows that the bare compact soil has only about 20 per cent. of moisture at the depth of two feet, while the soil which was plowed and subsoiled, as shown in Chart XXVII., p. 608, contained at the same depth about 22 per cent. While the bare compact soil (see Chart I., p. 585) contained only about 26 per cent. of water at the depth of three to six inches, and maintained this amount steadily throughout the season, the soil which had been thoroughly loosened to the depth of thirteen inches (Chart XXVII., p. 608) had at this depth 33 per cent. in May, but this amount was gradually reduced until September, when there was only 30 per cent. Two causes of the subsoil being moister in the subsoiled land are suggested:

(1) The soil which had been loosened to a depth of thirteen inches may have allowed the rainwater to percolate to a greater depth, thus increasing the water supply at the depth of twenty-four inches.

(2) The looser soil and upper subsoil may have retarded the upward flow of capillary water, thus conserving in the subsoil more of the water which was received. Opening the soil to the easy penetration of water is in one way an advantage, while the injurious effect of thus loosening it by subsoiling results in

CHART XXVII.—Loosening the Soil and Subsoil Aids the Rainfall to Penetrate Deep.



NOTE.—In chart XXVII, the amounts of moisture and temperatures at the depths three to six inches and at twenty-four inches are compared. The zone of soil nearer the surface on land plowed six inches deep and subsoiled seven inches deeper was much the moister. It became slightly drier as the season advanced while there was little change in the moisture at the depth of twenty-four inches. The temperature of the upper zone was several degrees warmer than at the lower electrodes. This difference gradually diminished through July and August and in September the temperature was higher at twenty-four inches deep. See page 607.

PLOWING IN SPRING VS. PLOWING IN THE FALL FOR WHEAT. 609

injury by the too free admission of air. It seems best to depend upon only a moderately deep furrow-slice to aid the water in penetrating the earth in our rather dry climates, leaving the sub-soil compact.

SUMMARY.

(1) Subsoiling often decreases the percentage of water in soils, though increasing it in the deeper subsoil.

(2) In districts where the rainfall is not over abundant subsoiling lessens the yield of crops on land already sufficiently open or porous.

(3) Subsoiling is expensive and is not profitable under most conditions in Minnesota.

PLOWING IN SPRING VS. PLOWING IN THE FALL FOR WHEAT.

In Table CXLIII. are given the yields per acre of wheat grown on fall-plowed land and on spring-plowed land. The results of three years are averaged and the average yields are equal. The North Dakota Station has averaged results of trials on Red River Valley land. They give the average for fall plowing at 19.2 bushels of wheat per acre and the average for spring plowing at one bushel less.

TABLE CXLIII.—Spring vs. Fall Plowing for Wheat in Bushels.

	1896		1897		1898		Totals		No. of trials
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
Grand Averages	7.9	10.3	8.0	7.8	26.8	24.9	42.7 14.2	42.7 14.2	3

Where it is practicable to do so, plowing should be done in the fall (early fall plowing is the best) to relieve the pressure of work during our short spring seasons, when large areas must be planted quickly. Extensive practical experience would seem to indicate that plowing early in the autumn gives the best crops and prevents the ripening of many weed seeds. Weeds are plowed

under while yet green, other weed seeds start and are killed by frost, the stubble has more time after being turned under in which to decay, and the land lies fallow for a time, allowing some plant food to be elaborated and retained for the use of the crop early the next season. The early fall plowed land allows water of rainfall to enter and serves as a mulch to keep it there.

PLOWED VS. COMPACT SOIL FOR WHEAT.

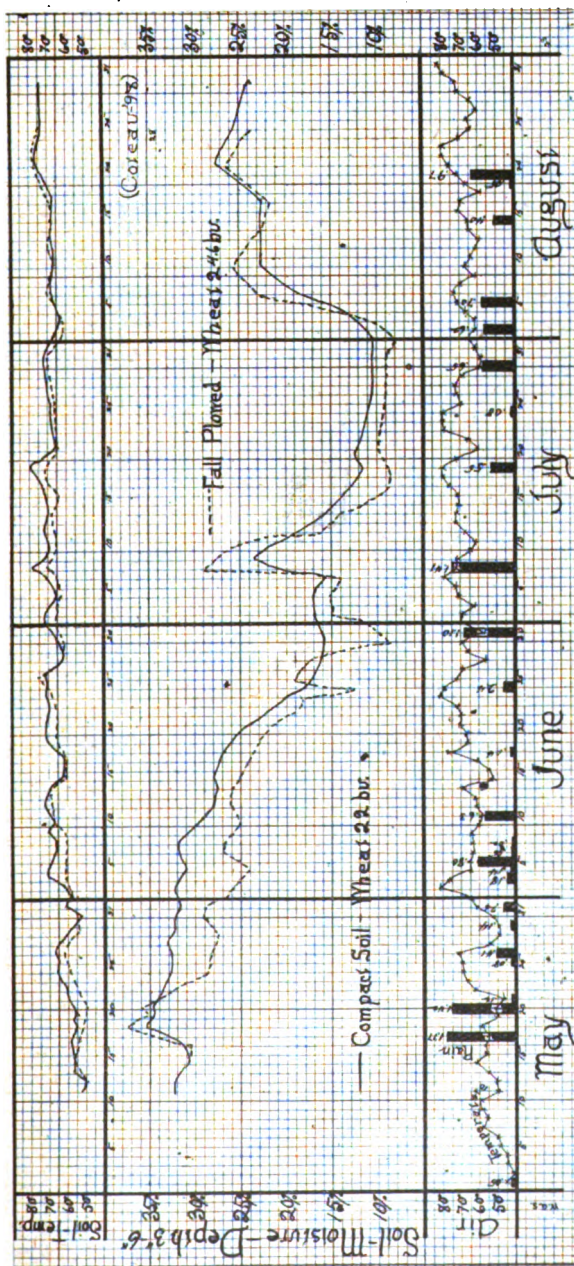
Table CXLIV. gives the results of sowing wheat in 1898 on land on which the wheat stubble had been plowed under in the fall, in comparison with wheat sowed on land from which the stubble was removed in the fall of 1897, leaving the surface hard and bare. The season was a rather favorable one for the unplowed plots. As a rule, wheat not only yields less where the land is not plowed, but the weeds have a better chance, both because the weed seeds are not destroyed nor buried too deep to germinate and because the less vigorous grain plants are not so strong in smothering young weeds. Here the yield was 2.6 bushels more on the plowed land, though the compact plots were otherwise in excellent condition. As a rule in Minnesota, this plan is not to be commended. Further west and northwest, where the drouths are more severe, this method of very little preparation will pay only occasionally. It is poor farming at best, and as compared with preparing our fields for wheat by means of other crops preceding them in the rotation, as grass, corn, etc., it is at the lowest end of the scale. It has been characterized as "wheat farming gone mad."

TABLE CXLIV.—Plowing vs. Compact Soil for Wheat.

Fall plowed.....	24.6 bu.
Compact soil	22.0 bu.

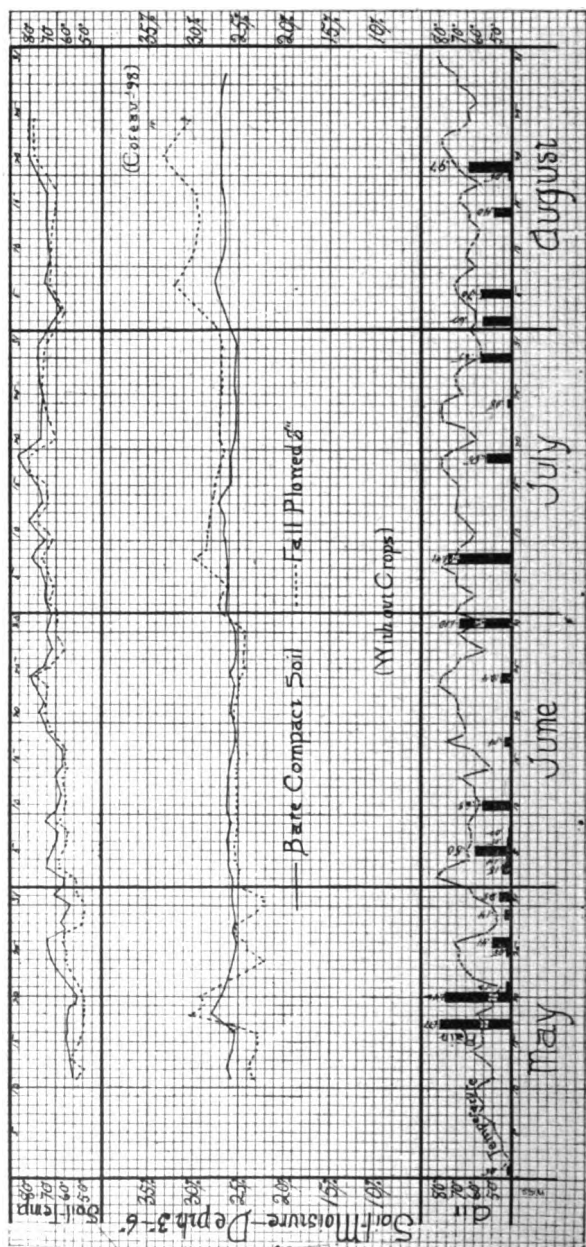
In Chart XXVIII., p. 611, it is shown that the compact soil was moister at the depth of three to six inches than the plowed soil. This is in part due to the greater need for water of the larger crop on the plowed area. The compact soil was less sensitive to the water of rains than the more open surface of the fall-plowed area. The better capillary conditions of the lower part of the furrow-slice in the compact soil enabled it to keep a better supply of moisture during the short periods of drought than that of the plowed soil.

CHART XXVIII.—Wheat on Plowed vs. Unplowed Stubble Land.



NOTE.—Chart XXVIII. shows that wheat on plowed soil yielded 2.6 bushels per acre more than unplowed land. There was more moisture at the depth of three to six inches in the compact soil until after harvest, when it was equal to that on the plowed plots. The temperature likewise was higher in the compact soil, except after the grain was harvested, when it was slightly lower than on the fall-plowed land. See page 610.

CHART XV.—Bare Compact Soil vs. Fall-plowed Soil — Without Crop.



NOTE.—Chart XV. shows that of two sets of plots not bearing crops in 1898 the one which was plowed in the fall was slightly moister in May and June, but drier in July and August. The temperature of the fall-plowed land remained a few degrees lower throughout the entire season. Both these soils remained very much more constant in their content of moisture than plots bearing crops, as may be seen by reference to the moisture curves representing plots bearing crops. The moisture in the fall-plowed soil fluctuated more than in the soil which had been left compact, and also showed a marked increase of moisture for the season. See p. 613.

That plowing opens up the soil so as to allow of ready absorption of rain is strongly shown in Chart XV., p. 612. The temperature of the plowed soil is also more moderate than that of the bare compact soil. The chart suggests that a watershed would cease to give so much of its waters to lakes and rivers if the surface were tilled. Many of the lakes and sloughs of the great prairie regions are drying up. The greater absorptive power of tilled soils is one reason for this drying up. It is a condition not to be wholly deplored, since we have the use of the water for valuable crops. It also means that early fall plowing is advantageous, because the season for absorbing rainfall is prolonged, to say nothing of the better elaboration of plant food that results.

It may be worthy of remark here also that our cultivated crops are doubtless larger and remove more moisture from the soil into the air than did the native grasses of the prairies, thus reducing the amount of moisture which formerly percolated downward and supplied springs and sloughs, which dried up soon after the prairies were brought under cultivation.

HARROWING GROWING WHEAT.

Table CXLV. gives the results for two years of experiments in harrowing wheat when it is a few inches high. It has

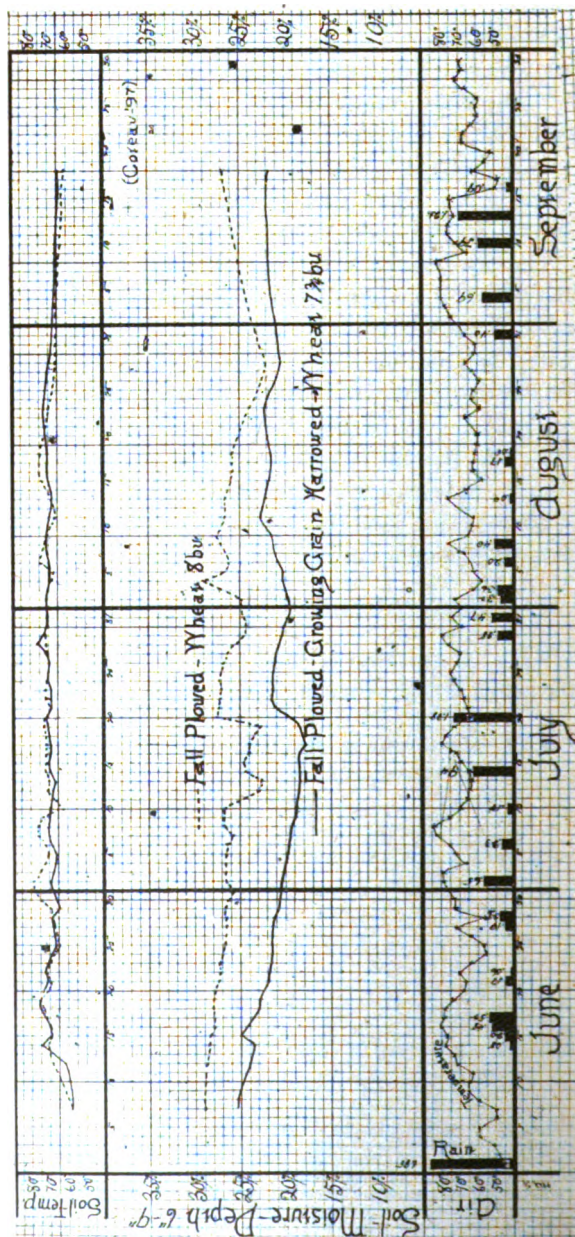
TABLE CXLV.—Harrowing vs. Not Harrowing Growing Wheat.

	1896		1897		Totals		No. Trials
	Not Harrowed	Harrowed	Not Harrowed	Harrowed	Not Harrowed	Harrowed	
Fall Plowed....	8.8	8.4	8.0	7.7	16.8	15.7	2
Averages.....	.....	.....	.....	.....	8.4	7.8	.....

been advocated by some that a light harrow would destroy many weeds and would improve the blanket of loose earth among the

NOTE.—The two plots represented in Chart XV., p. 612, grew no crops in 1898. One was left compact and kept bare of vegetation, while the other was fall-plowed and kept bare of vegetation. The compact soil, as shown by the moisture curve, held about twenty-five per cent. of moisture at a depth of three to six inches in the middle of May, and retained the same percentage till late in September. The fall-plowed plot had about twenty-four per cent. in the spring, and in the autumn this had been increased to thirty-one per cent. The temperature in the compact soil was a few degrees higher throughout the entire season.

CHART XX.—Harrowing Growing Wheat when a Few Inches High.



NOTE.—In Chart XX, the moisture curves show that in spite of the harrowing and of the slightly lessened stand of wheat the harrowing had a harmful, rather than a beneficial, effect on the amount of moisture that the soil contained at the depth of six to nine inches, as well as a bad effect on the yield of wheat. See pages 613, 615.

wheat plants. The results, so far as these few trials show, indicate that the injury to the plants is more than enough to offset any benefits which may arise from killing weeds and making the surface soil loose. In some experiments previously conducted the wheat was injured by harrowing, and the more harrowing the greater the injury.

We can probably do more to reduce the weeds in our wheat fields by means of previous crops grown in the rotation with wheat. Cultivated and grass crops reduce the weed seeds and also the annual and biennial weeds. These crops also prepare the soil for a thrifty growth of small grains which will smother out the weeds. Weeds must be attacked by all-round good farming as well as by special means.

Doubtless light harrowing during the first several days after seeding, before the plants are much developed, benefits the crop, but after the plants have reached the air it is easy to do more injury to the plants than good to the soil. Shepperd and Ten Eyck report one trial at Fargo, N. D., in which harrowing six days after sowing the wheat and two or three days before the plants came up gave an increased yield of two bushels per acre.

Since grain which is planted with a drill on well-prepared soil is all buried to an even depth, it may be harrowed after it sprouts with less injury than in case of wheat sown broadcast or even wheat which has been drilled in on poorly prepared land, where many of the seeds are near the surface.

BROADCASTING VS. DRILLING WHEAT.

During the past decade grain drills with shoes patterned somewhat after those used on corn planters have been highly developed. The best of these drills seem to be practicable in almost all soils and all conditions. They will not, however, work well on land in which corn stover is lying thickly. Now that corn binders are thoroughly practicable and corn stover is so thoroughly demonstrated to be a valuable food product, there is little excuse for allowing stalks to remain standing in the field on most Minnesota farms. Disk drills, on which disks take the place of shoes, are gaining prominence in some quarters. They may

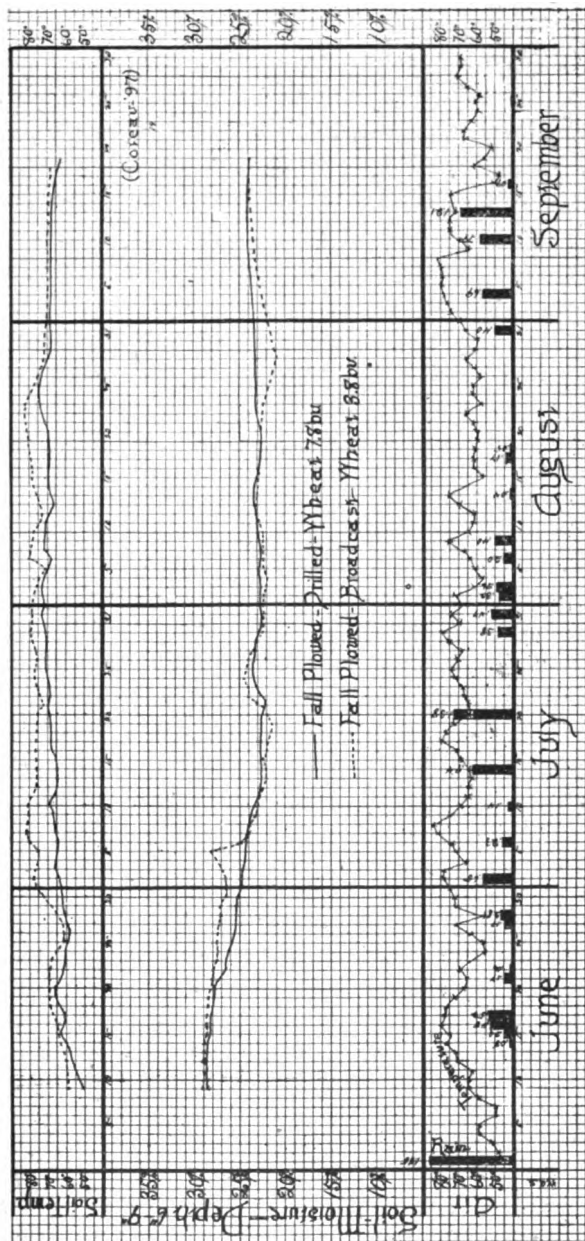
prove especially well adapted to drilling in grain or cornstalk land, and, on account of leaving the soil ridged so that it will not so easily drift, they may prove useful on fine soils exposed to severe winds and to many other conditions.

TABLE CXLVI.—Broadcasting vs. Drilling Wheat.

	1896		1897		Totals		No. trials
	Drilled	Broad-cast	Drilled	Broad-cast	Drilled	Broad-cast	
Fall Plowed.....	10.3	8.7	7.8	3.8	18.1	12.5	2
Averages.....					9.05	6.25	

Table CXLVI. compares the yield of wheat planted with a shoe drill and broadcasted in 1896, and again in 1897, on fall-plowed wheat stubble. The averages for both years are low, but it is under poor conditions that the drill excels. The drill is especially valuable in springs when the soil is dry. It places the seed at a uniform depth and in a narrow furrow freshly opened out, so that the seeds are laid in moist earth. Since the seeds are all at once well and evenly covered they germinate more uniformly early than in case the seeds are buried at uneven depths, as they are when sown broadcast and covered with the disk harrow, the spring tooth harrow or other cultivating implement. In seasons when moist cool weather follows seeding, broadcasting may result in as good crops as drilling, because the conditions are such that every seed will produce a vigorous plant whichever way planted, and almost regardless of whether it is buried shallow or medium deep. The drill requires less seed because a larger percentage of the seeds buried at a uniform depth will germinate and fewer seeds are required to produce a full stand. It is especially important that those who have drouthy soils use a drill, though the drill is best for even heavy, moist soils under most conditions. Very few hoe drills are now sold in Minnesota. Press wheels behind the shoes of shoe drills are not now considered so important as was generally believed several years since. These press wheels are probably useful further west, where the soils are frequently very dry at seeding time, and would be useful in western Minnesota in exceptionally dry springs.

CHART XIX.—Drilled vs. Broadcasted Wheat.



The especially low yield of broadcasting shown in the table on p. 616 for the year 1897 is very significant. A severe frost May 31st destroyed about one-half of the wheat plants on the broadcasted plot, while of the drilled wheats there were but few plants permanently injured. The drilled wheats were more deeply and strongly rooted than those of the broadcasted plots, the "crown" being deeper in the soil; hence they withstood the frost better.

CULTIVATING WHEAT IN WIDE DRILLS.

In Table CXLVII. are given the results of several trials of wheat grown in drills twenty-one and fourteen inches apart and cultivated, as compared with wheat sown in the ordinary way in drills seven inches apart and not cultivated. These trials cover the years 1896 and 1897, each yield given for each year being the average of the yield of three plots. The grand averages tell the story so emphatically that no discussion is necessary further than to say that the yield is reduced and the further apart the drills the less the yield. It is urged by those who favor this method that about one-half as much seed is needed. While this is true, it is more than offset by the extra cost of cultivating between the drills. There is nothing to warrant the use of this method in Minnesota. It has been suggested that, instead of using half the ordinary amount of seeds in the wide drills, better results would be obtained by sowing the full amount of seed.

TABLE CXLVII—Cultivating Wheat in Wide Drills.

	1896			1897			Totals		
	7 Drills	14 Drills	21 Drills	7 Drills	14 Drills	21 Drills	7 Drills	14 Drills	21 Drills
Fall Plowing.	8.8	9.2	7.8	8.0	4.6	4.1	16.8	13.9	11.9
Averages							8.4	6.9	5.9

STABLE MANURE FOR WHEAT.

As a rule in Minnesota farming, stable manure would better be applied to some crop, as grass or corn, which is grown in the rotation preparatory to the crop of wheat than to the wheat crop itself. Manure added direct to the wheat often makes the crop leafy, and on heavy soils it may even cause lodging and thereby do more injury than good. This danger does not obtain.

however, in the Coteau soils, which are naturally not very rich and are now somewhat worn by cropping to grain. Reference to Table CXLVIII. shows the proportion of straw to wheat to be less, if anything, in the manured areas than on the unmanured land. These soils lack humus, but on the other hand they abound in soluble mineral salts. Hence the yield of the crop is increased where humus and nitrogen are added to the soil. Twenty tons per acre is not sufficient to make the growth of straw too strong, but this amount increases the yield of the grain and its quality also. Even here it is recognized that the manure would yield far more profits per load if applied first to corn or grass and the wheat brought on the first or second year thereafter.

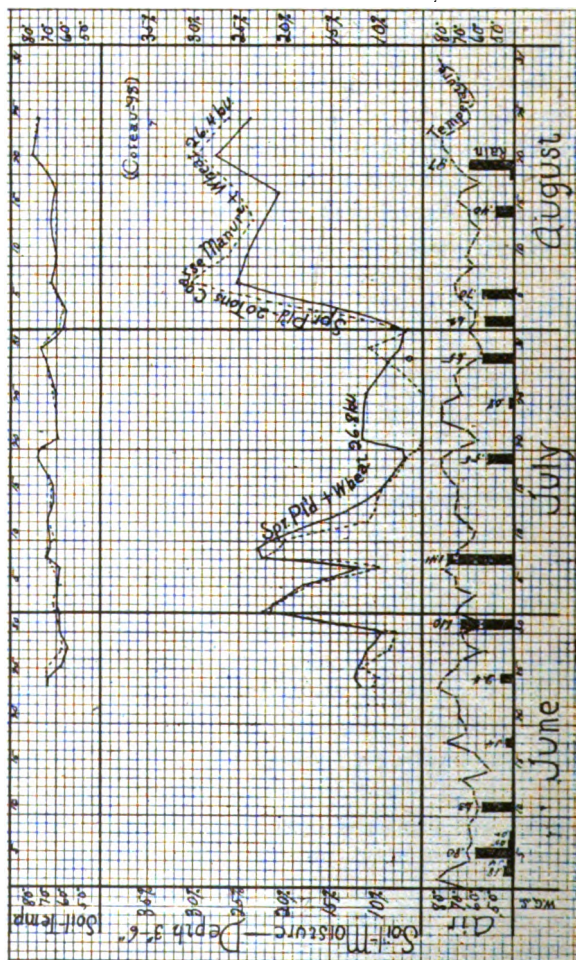
TABLE CXLVIII — Manuring vs. Not Manuring for Wheat.

	1896		1897		1898		Totals		Av. Proportion Grain to Straw.	
	Not Manured	Manured	Not Manured	Manured	Not Manured	Manured	Not Manured	Manured	Not Manured 1 to	Manured 1 to
Spring Plowing.....	7.9	20.4	8.0	17.3	26.8	26.4	45.7	64.1	2.4	2.2
Spr. Plow. and S. S. P.	8.3	14.3	9.1	14.3	26.5	25.5	43.9	54.1	2.6	2.24
Fall Plowing.....	10.3	12.5	7.8	10.3	24.6	24.6	42.7	47.4	2.5	2.5
Grand Totals							129.3	165.6	7.5	6.94
Grand Averages.....							14.36	18.40	2.50	2.31

Table CXLVIII. gives the yields for 1896, 1897 and 1898, each of which are made up by averaging the yields of two or three plots. While the grand-averages show that twenty tons of manure will increase the yield of wheat on this land several bushels per acre, the manuring was primarily done that we might study the influence of vegetable matter on the moisture of the soil.

The material increase in the yields of wheat from the application of stable manure on this comparatively new soil speaks emphatically in favor of the economy of producing and applying large quantities of manure on our farms, especially those which are lacking in humus and nitrogen. The range of increase shown in Table CXLVIII. is from 12.5 bushels per acre down to nothing, and in one case a decrease of one bushel is shown.

CHART VII.—Coarse Manure on Spring-plowed Land.



NOTE.—Plots on which twenty tons of unrotted manure plowed under in the spring of 1898 produced slightly less wheat than plots to which no manure was applied. Here the electrodes were placed at a depth of three to six inches. The temperatures were practically the same throughout the season, as is shown by the temperature curves at the top of Charts VII. and XVII., p. 621. During the earlier part of the season the soil at 8 to 6 inches deep was slightly drier on the manured plots, but after the crop was harvested the lower part of the furrow-slice in the manured plots became moister than those not manured, though the effect is not very marked. To coat the coarse manure had become somewhat rotted and more intimately mixed with the soil, thus enabling it to aid in holding moisture in the soil at the depth where the electrodes were placed.

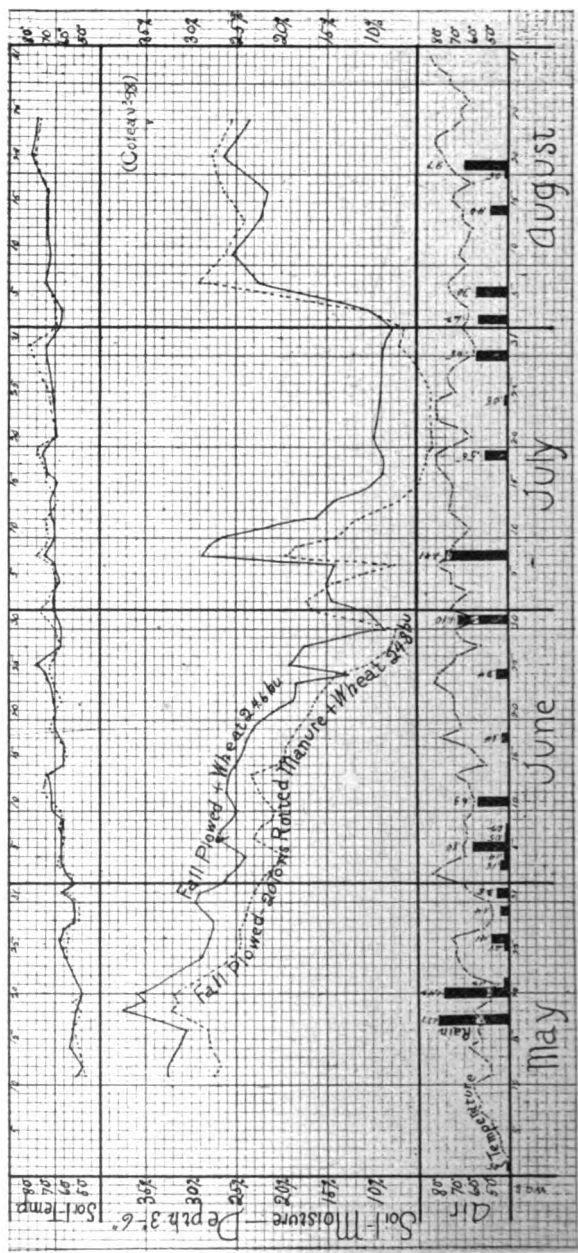
The log is divided into four main sections, one for each month: June, July, August, and September. Each section contains a series of plots for different variables:

- Temperature:**
 - Air Temp:** Plotted at the top of each month's section, showing daily fluctuations. The scale ranges from 60 to 80.
 - Soil Moisture:** Plotted below the air temperature, showing moisture levels at various depths. The scale ranges from 0 to 100.
 - Soil Temp:** Plotted below the soil moisture, showing soil temperature at various depths. The scale ranges from 60 to 80.
- Precipitation:** Plotted as vertical bars at the bottom of each month's section. The scale ranges from 0 to 10.
- Wind:** Plotted as a line graph at the bottom of each month's section, showing wind speed and direction. The scale ranges from 0 to 10.

The log also includes a section for "Soil Moisture" at the bottom, which is a summary of the moisture readings for the entire year. This section shows a general trend of decreasing moisture from June to September, with a significant drop in August and September.

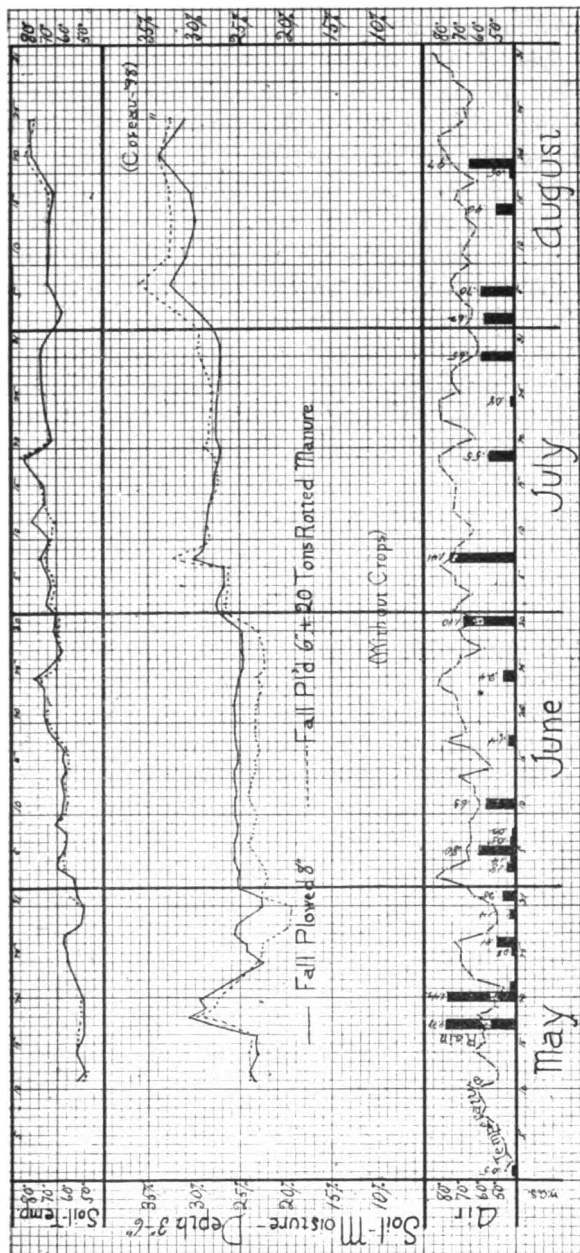
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CHART VIII.—Rotted Manure on Fall-plowed Land for Wheat.



NOTE.—In 1898 land into which twenty tons of rotted manure was plowed the fall previous, as shown in chart VIII, yielded two-tenths of a bushel more wheat than did land to which no manure had been applied, the land in 1898 being already quite well enriched. The manure had the effect of drying the soil at the depth of 3 to 6 inches earlier in the season, as is shown by the moisture curves. But after the crop was harvested, when the manure had become more intimately associated with the soil, the percentage of moisture in the lower part of the furrow-slice, where the electrodes were placed at the depth of three to six inches. See page 624.

CHART XI.—Rotted Manure and Fall-plowed Land—Without Crop.



NOTE.—On the ends of the plots mentioned under the last heading and in Chart VIII., page 622, the wheat was removed by hand as soon as it appeared above ground, and electrodes were placed in at the depth of three to six inches, that the effect of the manure might be studied without the effect of a crop. No change was produced by the manure in the temperature of the soil. Early in the season the manure made the soil drier, but late in the season, when it had become better incorporated with the soil, it assisted in holding more water in the lower part of the furrow slice. See page 624.

In general, it would appear that either rotted or unrotted manure plowed under in the fall or in the spring makes the furrow-slice drier during the earlier part of the summer in a dry region, but as the season advances it becomes more intimately associated with the soil, both chemically and physically, and then makes the soil more retentive of moisture. It was at first thought that the wheat roots might have been especially developed in the rich zone of soil containing the manure. This would result in the plants securing the excess of moisture there provided by the manure. But an examination of Chart XI., p. 623, will show that on the plot not bearing a crop the manure reduced the moisture in the soil early in the season and that later it increased the moisture, showing quite decidedly that organic matter, once it becomes well incorporated with the soil, tends to increase its water holding capacity. Doubtless the effect of the coarse manure early in the season is to so loosen the soil that it acts more strongly as a mulch, holding water in the subsoil by not allowing it to so easily rise through the furrow-slice by capillary action.

These soil moisture studies have strongly suggested the thought that in our warm, dry summers our common field crops adjust themselves to the conditions and feed deep in the soil. Where the plant can find no moisture through which to get its food in the upper six inches or foot of soil, its main feeding zone is below these depths and a foot or more in depth. Doubtless the zone of greatest activity of bacterial life is also just beneath the bottom of the dry zone. The water holding capacity and the richness in plant food of the subsoil to the depth of several feet are of greater interest and importance in a drouthy country than in one with an abundance of rainfall. Under conditions of extreme drouth where the entire furrow slice, and probably as much more of the subsoil, must be only a mulch over the moister subsoil in which the plant roots feed and in which bacterial life finds sufficient moisture for its operations, the quality of the subsoil is very important. Purchasers of farm lands in dry climates should make more than the customary difference in price between those lands which have a deep, retentive, not too close, subsoil of mixed clay and sand and those in which the subsoil is too open because composed largely of sand and gravel.

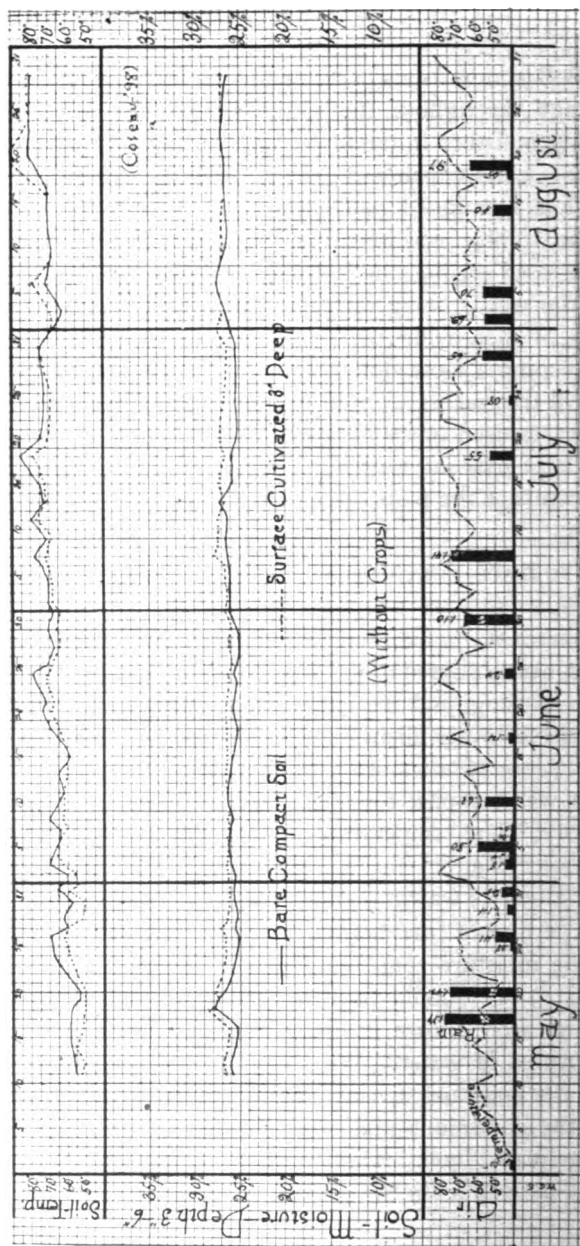
CULTIVATION CONSERVES SOIL MOISTURE.

In 1898 comparisons were made to learn what effect frequent tillage throughout the summer, and also plowing, have on retaining moisture in the lower part of the furrow-slice and in the subsoil. Land which had grown wheat in 1897 similar to that used in plots mentioned in Charts I. to XXIII., inclusive, was used. The stubble was removed from the several plots which were to be used on the duplicate series. One was left bare and compact, the weeds being removed through the summer without disturbing or mellowing the soil. Another was cultivated frequently, keeping a loose dust mulch on the surface for the entire season. All treatments were in duplicate and the average results are in all cases used in the charts. The plot which was left compact and kept bare of vegetation was used as a standard with which to compare the plots otherwise treated.

SURFACE CULTIVATION CONSERVES MOISTURE.

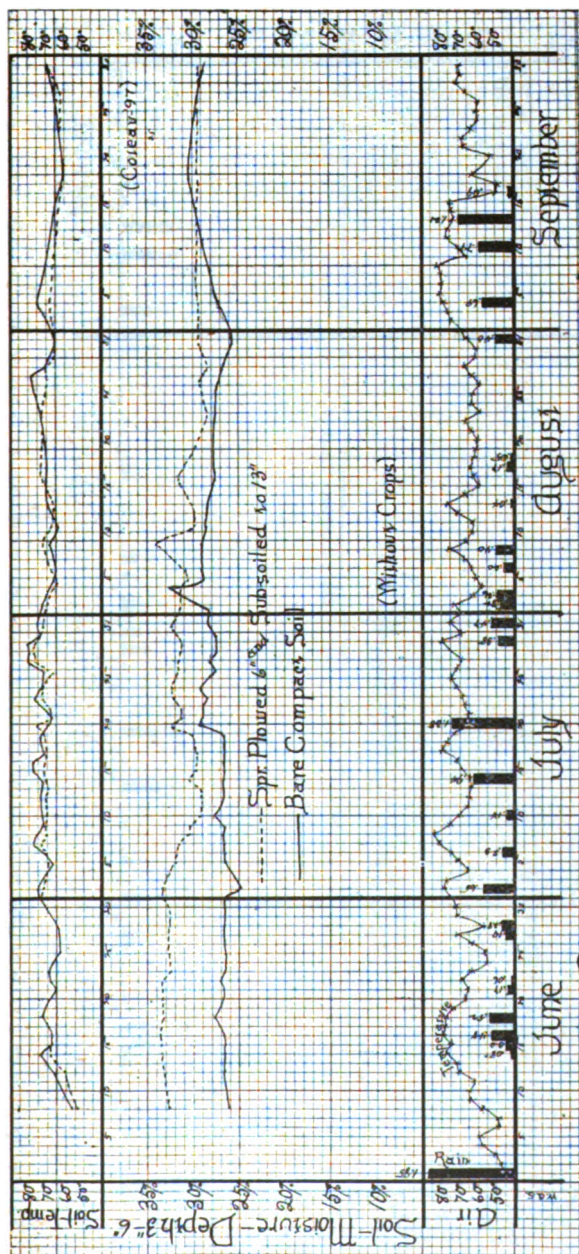
In Chart XII., p. 626, the bare compact plot is compared with the soil frequently stirred to the depth of three inches. The results are very surprising, and the experiment will be repeated. At the depth of three to six inches the cultivated soil had only about 1 per cent. more of moisture during most of the season than the soil which was compact to its surface, and late in the season it had no more. The temperature of the cultivated soil was a few degrees cooler than in the compact soil except in the autumn, when it retained its warmth longer than the compact soil. Should further experiments corroborate this result attaching less importance to the moisture conserving power of the dust mulch, (see pp. 626, 634) we should have a further reason for destroying weeds, which were shown (pages 588 to 591, incl.) to waste such large quantities of water. We should also have stronger suspicions that the constant stirring of the soil in between-row tillage improves the conditions under which soil bacteria work best in elaborating plant food. The effect of conserving moisture in the subsoil, as well as in the plowed zone of soil, is being further studied.

CHART XII.—Conserving Moisture by Tillage Between Rows.



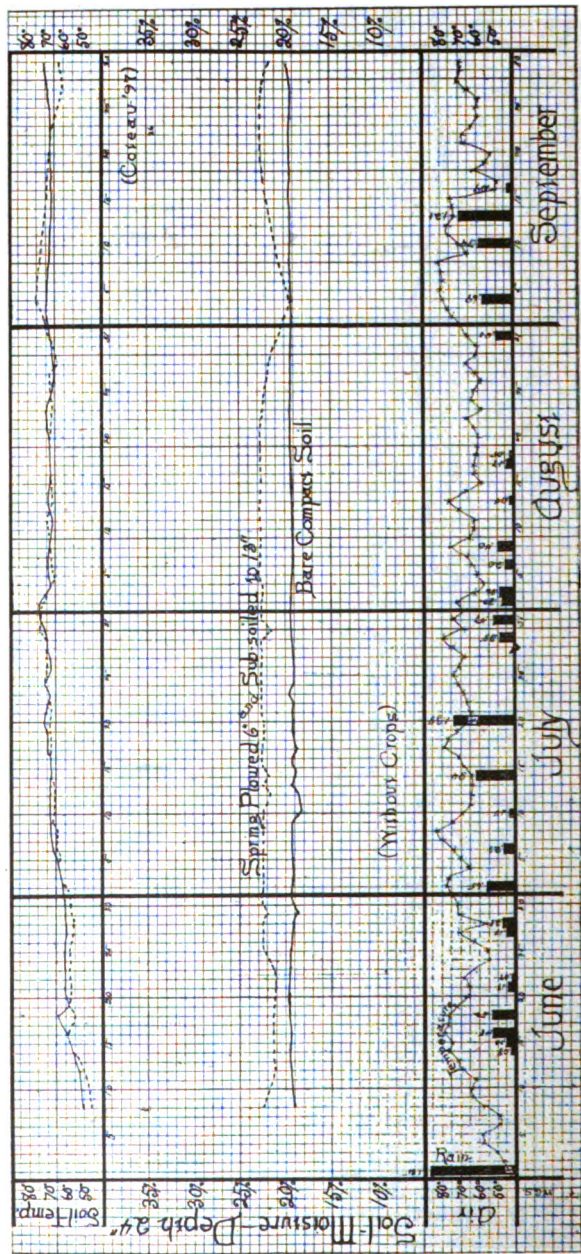
NOTE.—In Chart XII, the moisture at the depth of three to six inches in 1898 is shown in a plot of soil with surface left compact and kept bare of vegetation. Compared with it is soil which was kept stirred throughout the season to the depth of 8 inches. The cultivated soil had only about one per cent. more of moisture than the compact soil, but it was a few degrees cooler. See p. 625.

CHART XXV.—Moisture at 3 to 6 Inches Deep in Bare Compact Soil Compared with Plowed and Subsoiled Land.



Notes.—In Chart XXV, are displayed the moisture determinations at the depth of three to six inches for a bare compact soil and adjacent plots which were spring plowed to the depth of six inches and subsoiled seven inches deeper and kept bare of vegetation. Early in the season the plowed soil contained six per cent. more moisture than the compact soil. This difference was gradually lessened by the compact soil becoming moister and the plowed soil becoming drier at the depth named until the middle of September, when the two soils were equally moist. The temperatures remained about the same on the two plots throughout the season. See p. 629.

CHART XXVI.—Moisture in Bare Compact Soil Compared with Plowed and Subsoiled Land at 24 Inches Deep.



NORX.—Chart XXVI. gives a graphic record of the same plots and the same treatment as are recorded in chart XXV. p. 627, the difference being that the moisture and temperature determinations here recorded were made at the depth of twenty-four inches instead of at 8 to 6 inches. The plowed and subsoiled areas contained more moisture at this greater depth throughout the season than the compact area. The temperature curves cross and recross, showing that the temperature at this depth was alike in the two plots. See p. 629.

PLOWING AND SUBSOILING CONSERVE SOIL MOISTURE.

While the presence of a mulch of loose earth three inches deep throughout the season did not conserve much moisture in the soil at the depth of 3 to 6 inches, plowing six inches deep and subsoiling seven inches deeper resulted in the lower part of the furrow-slice being much moister. This was especially true early in the season, as is shown by comparing the moisture curves in Chart XXV., p. 627.

The moisture in the subsoil was much better conserved by the foot of loosened earth on the plots plowed and subsoiled than on the bare compact soil as shown by the moisture curves in Chart XXVI., p. 628. It would seem that one of the important functions of the plow is to conserve moisture in the soil and subsoil. It loosens the soil to the depth of several inches, making a more porous surface for the rainwater to enter, and it allows the water to percolate downward to the subsoil. When drouth occurs the porous soil is of too open a character for the water to readily rise through it by capillarity to be evaporated from the surface of the ground. If this proposition be as shown in Charts XXV., p. 627, and XXVI., p. 628, it is advantageous to have the rotation of crops so arranged that the soil is broken or cross-plowed at least at intervals of a few years, rather than lie unbroken, as in tame sod, for many years. The relation of soil moisture control and conservation is very intimately associated with the subject of crop rotations in climates which are subject to drouth. The most important question relating to the management of our fields is, What is the best method of rotating our crops? The question of how much water each crop leaves stored in the soil for the use of the succeeding crop is a secondary one, but is of great interest. The amount of water in the soil at the beginning of the season depends much upon the amount which was removed by the previous crop and upon the condition of the soil as to its taking in and retaining water during the growth of that crop and during the interval between the two crops.

EFFECT OF A MULCH OF STRAW ON SOIL MOISTURE AND TEMPERATURE.

In 1897, and again in 1898, a plot of compact soil, from which the wheat had been removed by hand, was covered with

a mulch of straw four inches deep. These plots were near the plots left bare and compact and those cultivated throughout to the depth of three inches. Their arrangement is shown in Fig. 272.

In Chart XIII., p. 631, the plot mulched with straw in 1898 is compared with the adjacent plot of bare compact soil. The moisture curves show that the mulched soil at the depth of three to six inches contained over 5 per cent. more moisture than the bare soil. The difference was greater in the dry, warm weather of mid-summer, when the straw prevented evaporation, than early or late in the season. That the greater part of a small rainfall readily penetrated through a straw mulch four inches thick is shown by the manner in which the dotted moisture curve responds to every rainfall of over half an inch. The electrodes in these plots re-

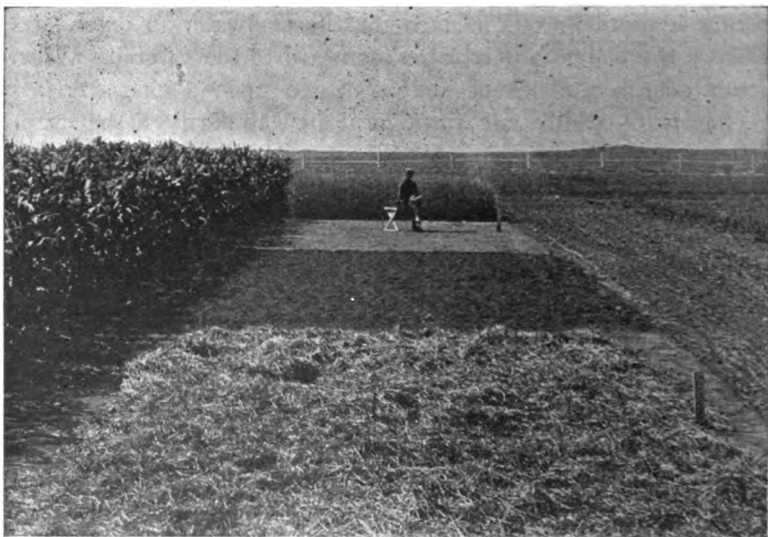
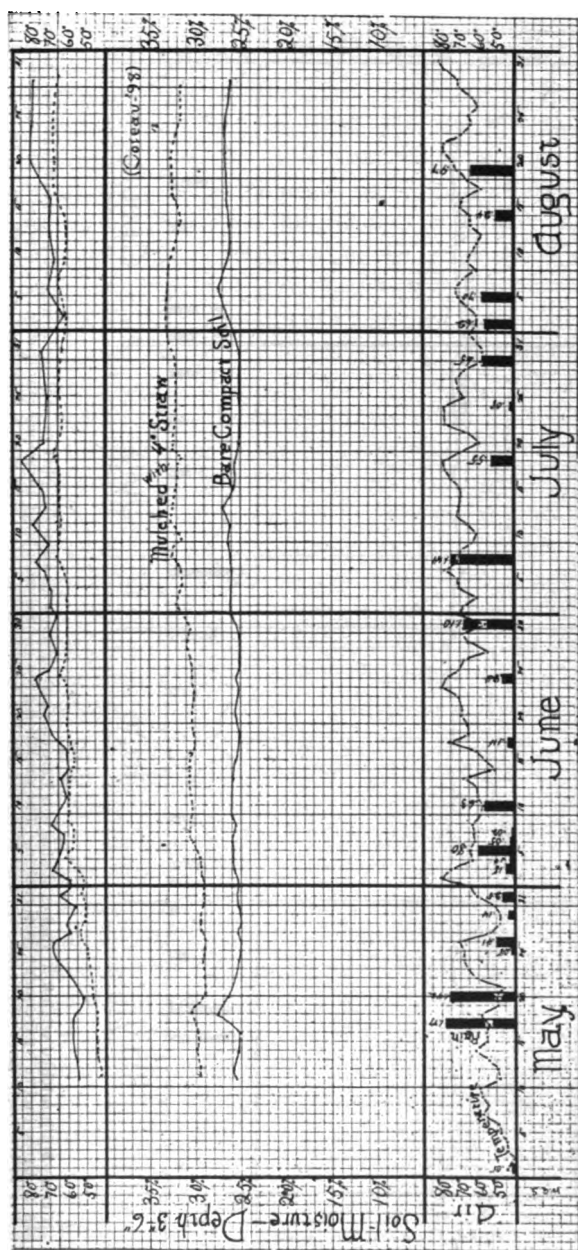


Fig. 272.—The nearest plot is compact soil mulched with straw; the second is bare of crop and cultivated to the depth of three inches; the third, where the man is using the electrical device, is bare and compact; the fourth is wheat on a compact soil. At the left is the plot of thoroughly cultivated corn. See pages 586, 587, 626 631.

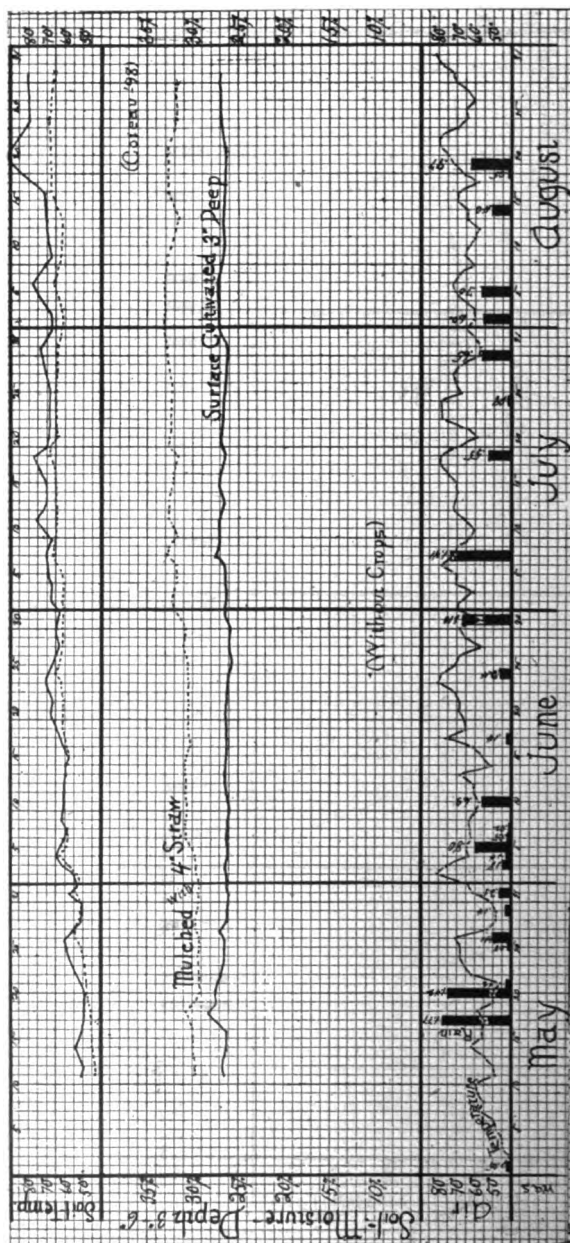
sponded to the rains nearly as sharply as did those in the bare compact soil. The temperature at the depth of three to six inches was several degrees lower than in the bare plot, and it did not fluctuate so sharply with the temperature of the air and with the amount of sunshine, as is shown in the temperature curves at the top of the chart.

CHART XIII.—Bare Compact Soil and Soil Mulched with Straw.



NOTE.—Soil mulched with four inches of straw compared with soil left compact and kept bare of vegetation. The mulched soil is much more moist at the depth of 3 to 6 inches and the temperature is much cooler. That the rain water penetrates through the straw mulch is shown by the fact that the dotted curve rises after every considerable shower. The moisture increased throughout the growing months in the mulched soil, while in the bare soil it remained almost constant. The temperature of the bare soil raised with the temperature of the weather, while in the mulched area the temperature remained more uniform. See page 680.

CHART XIV.—Bare Cultivated Soil and Soil Mulched with Straw.



NOTE.—Soil mulched with four inches of straw is here compared with an adjacent plot on which the surface was kept mellowed to the depth of three inches by frequent cultivation. The mulched area contained about three per cent. more of moisture at the depth of 3 to 6 inches in the early part of the season, and this was gradually increased until there was a difference of six per cent., the per cent. of moisture remaining constant in the cultivated soil. The temperature was slightly lower in the mulched soil than in the cultivated soil, and varied less with the changes in air temperature and intensity of the sun. The difference in temperature increased as the season advanced. See page 632.

In Chart XIV., p. 632, the soil mulched with straw is compared with the cultivated soil. The straw mulch caused the soil at the depth of three to six inches to be much more moist than the cultivated soil. The mulched soil became moister as the season advanced, while the per cent. of water in the cultivated area remained at about 25 per cent. The cultivated soil was a few degrees warmer than the mulched soil early in the season, and in the latter part of the season the temperature curves show it to have been several degrees warmer.

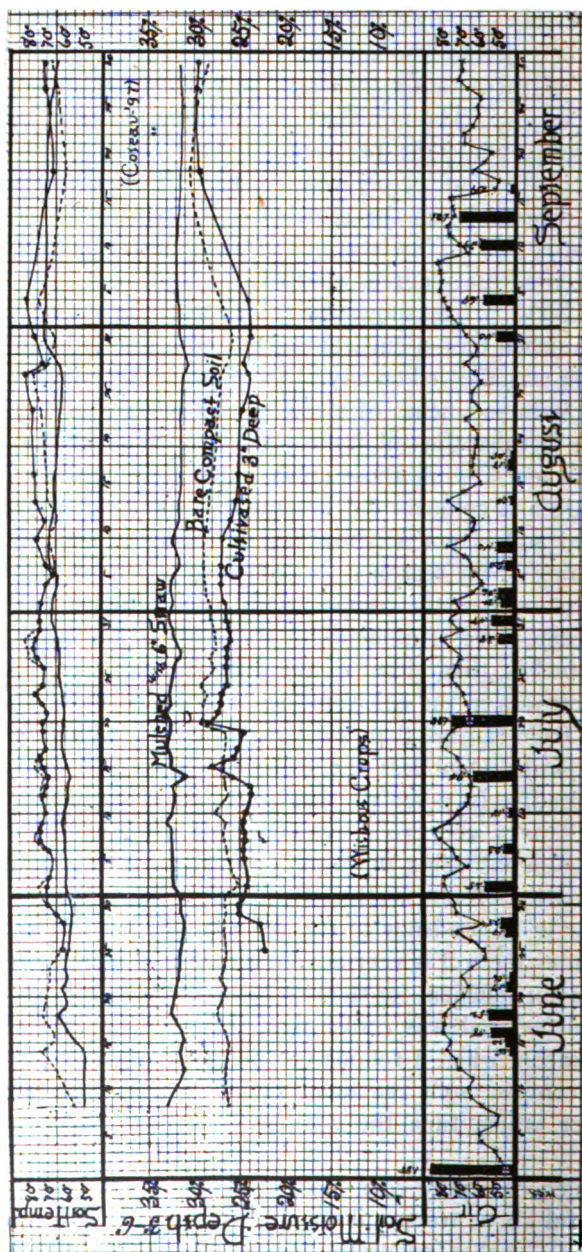
Chart XXIV., p. 634, shows the record made on three plots in 1897, on a mulched plot, a cultivated plot and a plot left compact. No vegetation was allowed on any of the plots. The mulched plot was covered with six inches of straw, which proved too thick, as shown by the fact that the soil in this plot became no more moist as the season advanced, while those areas which were cultivated and those left bare and compact did become more moist. Strangely, the cultivated soil is not so moist as the compact soil, though at the beginning of the season it was much drier, and it increased in moisture more than the compact soil. The mulched soil had several per cent. more of moisture at the depth of the electrodes, three to six inches, than either of the other plots.

The electrodes in the cultivated soil responded more quickly to the water from rainfall than did those in either the mulched or the compact soil. Doubtless the cultivated surface enabled the water to more freely percolate downward to the depth of the electrodes. This is very good evidence that a cultivated soil is more effective in absorbing the water from rains than is a harder surface, a matter of no small consequence. Whatever retards the rainwater in its tendency to run off over the surface and induces it to enter the soil is very advantageous in a country where the rainfall is not sufficient for the best results.

The mulched soil was cooler than the others except at the end of the season, when it retained its warmth longer. The cultivated and compact soils remained equally warm until early in August, after which time the compact soil was the cooler of the two.

The mulch of straw, corn stover, hay or other coarse material is useful about trees and shrubs. If laid flat and not too thick, two to five inches, owing to the nature of the material, so as

CHART XXIV.—Bare Soil Compared with Plots Covered with Straw Mulch and Dirt Mulch.



NOTE:—In Chart XXIV, the temperature and moisture records of three plots without crops are graphically compared. One plot was left compact; another was cultivated frequently, keeping a "dust mulch," three inches deep; and the third was covered with a mulch of straw four inches in depth. Strangely the cultivated soil had at the depth of 3 to 6 inches a few per cent. less of moisture than the compact soil and the mulched soil had several per cent. more than the compact soil. In September the compact and cultivated areas became almost as moist as the mulched areas. Early in the season the compact and cultivated soils were at the same temperature while the mulched area was several degrees cooler. During August and September the cultivated soil was a few degrees warmer than the compact soil. Late in September the mulched soil became as warm as the cultivated soil and warmer than the compact soil. See page 638.

to let the water pass through it into the soil, it doubtless conserves water for the plants. Superintendent Gregg has found it useful to place a mulch along either side of his willow hedges after the time of cultivating has passed, when they are several years old. With young trees the mulch hardly takes the place of cultivation, but the wiser plan seems to be to keep the soil well cultivated and free of grass and other weeds until the trees are several years old. Then the mulch aids in keeping the soil moist and in smothering out weeds which would rob the tree of much of its share of moisture. Where prairie or field fires are likely to occur the mulch is a menace to trees, while clean cultivation is a perfect protection. The mulch about trees set in a small hole in the sod will not take the place of cultivation in producing satisfactory growth in young trees of any kind. The mulch seems more adapted to use in manuring and aiding the older tree, which is nearly large enough, to so shade the land as to prevent the growth of weeds near it which would rob it of moisture.

Likewise, in the care of strawberries, and such shrub fruits as raspberries, currants, etc., the mulch is doubtless best used as an adjunct in between-row tillage. A layer of straw placed between the rows in midsummer, after the cultivator has been run for two or three months, will often do the plants much good. This plan secures the advantages of the cultivation early in the season, when moisture is more abundant and the mulch conserves the moisture during the drougtier period, from the middle of July until the autumn, that the plants may have a supply of water in the autumn and in the spring.

FORAGE CROPS AT COTEAU FARM.

W. M. HAYS AND WM. G. SMITH.

While the main object of field experiment work has been to study crop rotation and field management, several minor experiments have been carried on.

MEADOW AND PASTURE CROPS.

In Table CXLIX., p. 637, are arranged many facts gathered from experiments with a series of plots of grasses and clovers tested for many years. These plots were first sown in the spring of 1895 to the crop named in column 2. The yields of these crops in 1896 are given in column 3. The winter of 1896-97 was severe, and all but the hardiest were killed out, thus giving a good test of the hardiness of the numerous kinds. In column 4 are shown the yields of these grasses which endured the winter. In case of mixtures of grasses, or grasses and clovers, the yields for 1897 represent only those grasses in each mixture which are shown to have been hardy in the plots in which they were grown separately.

Many plots were plowed up in the summer of 1896 because no stand had been secured. Others in which the plants had died in the severe winter of 1896-97, were plowed in the spring of 1897. These were planted in the spring of 1897 to the crops entered in column 5. In column 6 are given yields for 1898, and in column 7 are given the dates in spring when the various plots first had herbage sufficiently large for pasturage. The results given in this table are characteristic of plot tests of grasses at University Farm and at various other experiment stations in the prairie west. The really valuable meadow and pasture plants are unfortunately few in number. *Bromus inermis* is really the only new grass the merits of which have been proven.

FORAGE CROPS AT COTEAU FARM.

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TABLE CXLIX. Grasses—Varieties and Mixtures for 1896-7-8. Coteau Farm.

Plot No.	Grasses Sown in Spring, 1895.	Tons yield per acre. 1896	Tons yield per acre. 1897	Grasses Sown in Spring of 1897.	Tons yield per acre. 1898	Ready for pasture
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Bromus Inermis and clover 12 in. drills		1.20		3.2	May 8
2	Red clo. & orchard grass 24 in. drills	plowed up		Native rye grass 20lb	2.8	June 1
3	Red clo. & orchard grass 12 in. drills	plowed up		Summer fallowed...		
4	Red clo & tim drills 24 in. apart.....	2.13		" "		
5	Red clo & tim drills 12 in. apart.....	1.62		" "		
6	Sacaline	plowed up		Timothy 5 lbs., red clover 4 lbs.....		
7	Lathyrus sylvestris	plowed up		Bromus 10 lbs., Ky. Blue Grass 10 lbs.	1.78	June 1
8	Alfalfa 20lb.....	poor stand		Timothy 7 lbs., Red clover 5 lbs.....		
9	" 30lb.....	2.72	pastur'd	Bromus 20 lbs.....	1.54	June 4
10	Red clo. 24 in. drills	poor stand		Summer fallowed		
11	" 12 "	"		Bromus 20lb.....	1.39	
12	Tim. 8lb Red clo. 6 lb Broadcast.....	"		Red clover 5lb.....	1.97	June 4
13	Tim. 8lb Red top 6lb Red clover 3lb.....	1.45	0.84	Tim. 8lb red clo. 3lb Mam. clo. 3lb.....	1.98	" "
14	Tim. 8lb Red clo. 3lb crimson clo. 3lb.....	1.68	1.00	Summer fallowed		May 25
15	Bromus Inermis.....	2.32	0.91			
16	Br. Inermis 10lb Orchard grass 14lb	1.88	.80		{ 250lb per acre }	May 25
17	Orchard grass 20lb Red clover 4lb....	2.48		Summer fallowed		
18	White clover 3lb Tim. 6lb. Ky. Blue Grass 3lb Alsike 3lb	2.17	1.10		1.98	June 5
19	Tim 8lb red clo 3lb mammoth clo 3lb....	2.52		Tim. 8lb, red clo. 5lb	2.45	" 1
20	Tim. 8lb red clo. 3lb Alsike 3lb.....	2.65		Timothy.....	2.29	May 28
21	Tim. 8lb red clo 6lb Ky. Blue Grass 12lb.	1.87		Meadow Fescue 20lb	2.36	" 25
22				Red top 8lb.....	1.97	" "
23	Orchard grass 14lb Tim 5lb red clo. 3lb Alsike 1 1/2 lb.....	1.80		Orchard grass 20 lb..	2.47	" "
24	Bromus 15lb white clo. 1 1/2 lb.....					
	Ky Blue Grass 7lb Alsike 1 1/2 lb.....	fair stand		Bromus Inermis 25lb	3.43	" 15
25	Tall oat grass 28lb.	poor stand		Alsike clover 4lb.....	1.96	June 5
26	Meadow foxtail 24lb			Red clover 7lb.....	2.02	" 1
27	Timothy 11lb.....	1.34	1.46	Mammoth clover 7lb	2.27	May 20
28	Crimson clover.....	no stand		White clover 3lb.....		June 10
29	" 8lb.....			Summer fallowed		" 15
30	White clover 3lb.....	pastured				
31	Alsike " 4lb.....	fair		" "		
32	Mammoth clover....	stand		" "		
33	Red clover 8lb.....	0.82		Alfalfa 25lb.....	1.18	May 15
34	Powl meadow grass 20lb.....	poor stand				
35	Ky. Blue Grass 30lb.	1.17	1.30		1.35	" "
36	Red top 12lb.....	2.02	1.13			" 23
37		poor stand		Red clo. 5lb Tim. 6lb Ky. Blue Grass 20lb	1.42	June 1
38	Orchard grass.....	stand	1.00			May 28
39	Timothy 11lb.....			10 yr. old tim. sod...	1.50	" 25
40	8 yr old Timothy sod 3 yr old red clover & tim. sod.....	1.27	2.00			

ANNUAL PASTURE CROPS FOR STEERS.

Table CL. gives data of several preliminary experiments in pasturing annual crops at Coteau Farm in 1896. The relative yields of the several crops are surprising. Such crops as sorghum, oats, pats and rape, and the non-saccharine sorghums which sprout up from the crown and make a second growth of pasturage support steers longer than field peas or field corn, which do not again sprout up when eaten off. These figures are not given as averages. Other facts, such as the value of each crop in preparing soil for succeeding crops, in adding nitrogen to worn soils, cheapness of seeding, etc., are left for a future report. Rapid progress is being made in learning how to make and use pastures for the two very important purposes of feeding animals and preparing the land for grain and other crops.

TABLE CL.—Annual Pasture Crops for Cattle. Coteau Farm 1896.

Crops	No. of steers	Size of plot in rods	Days pastured		Total days pastured on plot	Days one acre would keep one steer
			1st time	2nd time		
Amber Cane	2	18x9½	88	19	52	97
Field Corn	1	5¼x9½	20	.....	20	59
Brown Dhoura	1	3x9½	7	6	13	80
Jerusalem Corn	1	3x9½	7	6	13	80
Oats	1	3x7½	7	8	15	106
Peas	1	3x9½]	7	1	8	45
Millet*	1	3x9½	10	6	16	90
Oats and Rape	1	3x9½	7	7	14	80
Oats and Peas	1	3x7½	7	2	9	64

At Coteau Farm a special effort is being made to determine the relative values of the different annual and rotation pastures or forage crops and prepare the land for grain and other crops which follow the pasture.

NOTE.—Much effort has been expended at University Farm and at the sub-experiment farms to devise methods of experimentation for gaining a better knowledge of field management in Minnesota. Much trouble has been met in devising a way of measuring the values of pasturage. Mere dry matter determinations of pasturage crops are useful, but to secure the value per acre of pasturage of various crops and pasture mixtures it must be fed in the natural way. To secure a knowledge of the value to succeeding crops from the rotation pasture, the pasturing must be done in the ordinary way in the rotation. Numerous methods have been tried with sheep, with cattle tethered, and cattle enclosed in fences. After much failure and some success a good working plan has been devised and is now in operation on many plots,—rather large plots, one-third acre to one acre, or even larger.



Fig. 265.—Sheep pasturing on field peas. On the left is the plot of peas for green manure. These plots are under trial comparing pasturing and green manuring as methods of preparing the land for wheat.

ANNUAL PASTURE CROPS FOR SHEEP.

In Table CLI., p. 641, are recorded the results of pasturing sheep at Coteau Farm in 1898 on plots planted to a succession of annual pasture crops. These crops were sown, primarily, to study

excepting where plots laid out in rotation experiments years ago are smaller; in no case, however, less than one-tenth of an acre in area. These plots are rectangular, usually two or three times as long as broad. Permanent wire fences are built along the edges of the plots, while temporary fences are strung across the ends. These portable end fences are removed to allow the team to turn in the sixteen foot alleys separating the series when plowing or planting the plots, and they may be taken from plot to plot as the cattle are removed from place to place. Thrifty grade beef steers weighing about 800 lbs. are chosen for these experiments. They are led to the barnyard for water or water is drawn to them, as convenience dictates. If there is not sufficient pasturage in the experiment plots the cattle are turned into the general pasture till other plots are ready. The steers are weighed frequently, but unless the plots are large and the pasturing period long the gain in weight is not used as a measure of the food supplied by the pasture. The weights are taken for a few days when the steers are placed on each pasture, and again when taken off so as to have a record of how each pasture was relished and caused the animal to thrive. Later on these pasture crops, "pasture mixtures" and succession of pasture crops which have proved best will be tested and compared on a larger scale, with longer feeding periods, that their relative feeding value may be accurately determined. At present the different crops are compared by determining the number of days one acre of each will support a 1,000 lb. steer. A sample of each pasture plot is taken at the time of turning the cattle on and the dry matter determined, that a record of the yield of dry matter per acre may be recorded and its value calculated by using standard analyses of the given crop at that age. These methods are being annually improved upon, and promise to be of great use in the extensive experiments the Minnesota Station has under way at its several experiment farms.

their effect on the amount of moisture and fertility left in the soil for the crop of wheat following. The value of pasturing the land in this manner, as compared with growing other crops for the purpose of plowing them under as green manure, as shown by the yield of the succeeding crop of wheat, was also under experiment. The table shows the large number of sheep kept per acre by each crop, and the superiority of the succession of crops in Plot 12. The plots were all in duplicate. Care was taken to plant all crops sown in summer rather deep with a shoe drill.

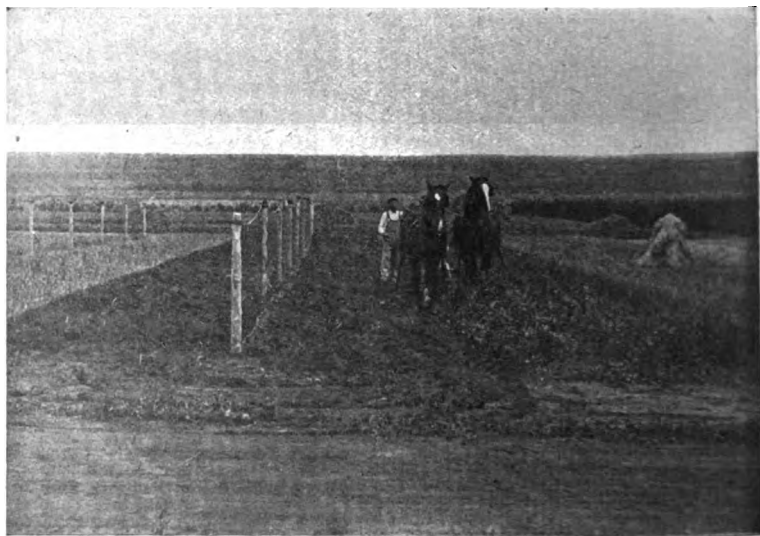


Fig. 266. —Plowing under field peas as green manure on plot beside another plot which was planted to similar crop and pastured.

Winter rye makes a good crop of very early pasturage. Peas sown late in the season do not thrive in our dry, hot summers, while corn, for the second planting, makes a large yield of sheep pasturage. Three, or even two, annual pasture crops

**TABLE CLI.—Sheep Pasturing on Summer Forage Crops.
Coteau Farm, 1898.**

Plot No.	Crop	Date Pastured	No. of Sheep	Size of Plot	Days Pastured	Days one Acre would keep one Sheep	Summar-ies for each Plot.	Average of both Plots.	
							Days one Acre would feed one Sheep.	Days one Acre would feed one Sheep.	
12	Winter Rye..	May 25	30	1/10 Acre	2	600	1950	1650	
	Corn.....	July 14	"	"	3	900			
	Rape.....	Sept. 15	"	"	1 1/2	450			
13	Peas.....	June 15	30	1/10 Acre	2	600	1350		
	Peas.....	Aug. 10	"	"	1 1/2	450			
	Rape.....	Oct. 5	"	"	1	300			

NOTE.—This table shows the number of days one acre will feed one sheep with the two systems of cropping to annual pastures.

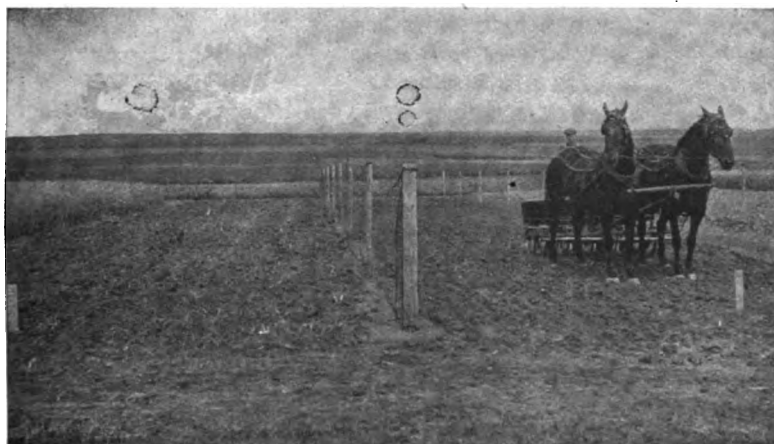


Fig. 267.—Seeding pasture and green manured plots to rape—the third crop of the season.

grown in one season, requiring that the land be plowed two or three times, cleaned the land of wild roses and many other weeds. The land was made more fertile, and in spite of the fact

that these leafy crops drew large quantities of water from the soil it is believed that the increased absorbing power of the soil caused more water to be conserved for the crop of wheat the next year. Experiments started from suggestions arising from this experiment, and running through a series of years, are now under way at Coteau Farm.

NOTE.—The method of testing pastures by means of sheep is similar to that used in testing pasture crops with steers. Plots one-third acre in area, or larger, are used and permanent fences built or hurdles are used. Yearling ewes from Supt. Gregg's large flock of sheep are used. This avoids the use of a flock of mixed ewes and lambs and gives lots of growing animals whose thrift will record the nutritive qualities of the pasturage. The dry matter per acre and the number of sheep each crop will sustain for one day each time pastured, as well as the general gains of the sheep, are recorded.

SHELTER BELTS AT COTEAU FARM.

WM. G. SMITH.

A series of plots planted to forest trees at Coteau Farm in the spring of 1894 now present a most attractive appearance and have already encouraged many visitors to take courage in growing shelter belts in Southwestern Minnesota. This series of plots is on a north slope, north of an old cottonwood grove now containing only scattering trees.

A double-row willow hedge fifteen years old protects the new plantation on the south and west, and a new double-row hedge of willows was planted on its north border.

The protection afforded by the willows has made it possible to grow some deciduous and evergreen trees here which failed when planted in an exposed place southwest of the farmstead. The drying southwest winds of early spring and the cold drying winds of early winter when the soil is not yet covered with snow are very trying on many trees, while willows endure these severe conditions and may be grown to shelter those which must be planted where they have some protection. A second element in the successful growth of this forest belt of mixed planting has been constant summer cultivation among the trees. The rows were planted several feet apart and the cultivation with horse and hand hoes has been so thorough as to always have a dust blanket and to keep all weeds from growing. This has avoided loss of moisture through weeds and through the surface of the soil, conserving nearly all the rainfall for the use of the trees. The growth in five years has been so rapid that visitors are always surprised that such a large windbreak can be produced in so short a time.

SHELTER BELTS AT COTEAU FARM.

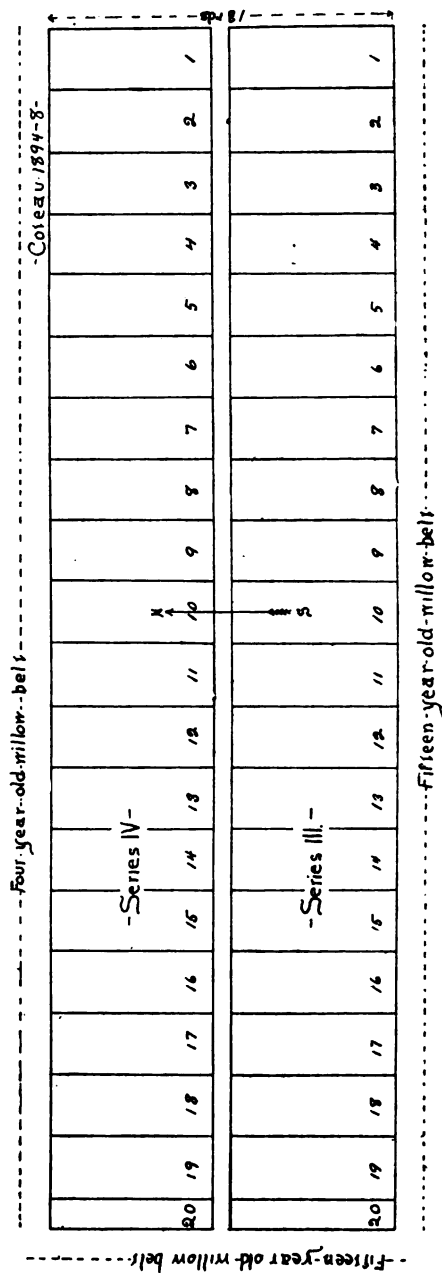


Fig. 284.—Arrangement of plots; also old willow hedges on south and west sides and double row hedge on the north.

The more intelligent farmers who visit this forest see the cause of its great success and go away with the mental attitude of "let us go and do likewise." There are already signs of renewed forest interest in this section and several thousand willow cuttings have been distributed from Coteau Farm. The fruit trees, especially the plums, are yielding immense quantities of large, luscious fruits in the forest, while the same varieties near by, but less protected, give smaller yields of poorer quality. It does not take a lifetime to grow a protection. The four-year-old willow hedge already stands fifteen feet high, and willow cuttings are so easily put in the soil and so easily cared for with a horse cultivator that there is but little excuse for a man to spend his life farming on the wind-swept prairies without a beautiful grove about his home. Intercourse with farmers who had spent much money and energy trying to get trees to grow, only to meet with failure, revealed the fact that they had not recognized the necessity of growing a protective hedge of willows or some equally quick growing trees, and had neglected to prepare the land well and properly and to cultivate the young trees.

To Supt. O. C. Gregg is due the credit of emphasizing the necessity of a protective hedge of quick growing trees like the willows and the caragana within which to plant the slower growing deciduous trees and the evergreens; also the need of thorough cultivation. To Prof. Green is due the selection of the varieties, and to Prof. Hays the arrangement of a system of plots with a view to determining the mixtures that give the best possible forest conditions of a shelter belt.

SUMMARY AND PRACTICAL NOTES ON COTEAU FARM EXPERIMENTS.

1. The roots of field crops are much longer, spread farther, and penetrate deeper than is generally believed, being four to six feet long, or longer.

2. How the water is absorbed by the soil, how it moves about in the soil, how it is evaporated from the surface, and how it is removed from the soil by growing crops, are illustrated.

3. Decaying plant substances mixed into the soil enable it to hold more water, and aid crops to better endure both drought and excessive rainfall.

4. Prof. Milton Whitney's electrical device for daily recording the moisture of soils was most satisfactory, greatly aiding in studying field management.

5. Practical methods of recording the value of pastures in using steers and sheep on experiment plots are reported.

6. That crops remove a very large amount of water from the soil is demonstrated in the field; wheat removing 523 tons per acre from the upper two feet of soil, or 261 pounds for each pound of dry matter of crop grown.

7. Weeds in a dry country waste enormous quantities of water, each pound of weeds reducing the growth of corn by two pounds. Clean farming conserves moisture for the useful plants, and useful plants produce more bulk as well as more value from a given amount of available moisture.

8. Subsurface packing in fall and in spring-plowed land had little effect in conserving soil moisture in or below the furrow slice, added only two-tenths of a bushel per acre to the yield of wheat in ten trials, and was not financially profitable.

9. Subsoiling probably increases the amount of water in the deeper subsoil, but decreases it in the furrow slice and upper zone of subsoil, thus often lessening the yields of grains, cultivated crops and root crops, in a drouthy country.

10. Sowing wheat or other spring grain on unplowed stubble land results in lessened yields, because the compact soil does not conserve moisture as well as the plowed furrow slice, and because more weeds grow, using moisture, plant food and room.

11. Plowing opens the surface of the ground so that rainwater can more readily enter; and the furrow slice in a dry climate, being loose and open, forms a most effective dirt mulch, retarding the flow of water to the surface, thus lessening evaporation and the waste of soil moisture.

12. Drilled grain usually yields better than broadcasted grain, and the shoe drill and disk drill have now been so perfected that they are adapted to nearly all conditions; the former probably being preferable in regions where the seed bed is free of corn stalks, the latter on farms where grains follow corn.

13. Wheat drilled about one-half bushel per acre in drills 14 and 18 inches apart, and cultivated, did not yield so well as wheat planted $1\frac{1}{4}$ bushels per acre in drills seven inches apart and not cultivated.

14. Ten tons per acre of stable manure increased the yield of wheat at Coteau Farm four bushels per acre, but decreased the moisture in the furrow slice the first year, increasing it the second year for the succeeding crop. Decaying vegetable matter has a peculiar value in droughty soils.

15. Surface cultivation between the rows conserves the moisture mainly by preventing the growth of weeds and their use of water; also by serving as a loose mulch of soil through which the capillary water cannot readily rise to be in contact with the moving air and be evaporated.

16. A mulch of straw or other material two to five inches thick—thickness advised in proportion to coarseness—allows the water of an ordinary rain to easily flow through it into the soil, but serves as a barrier to evaporation.

17. Mulching will not take the place of cultivation, but will supplement it; as around trees which have been culti-

vated until several years old, and among strawberries and small shrubs cultivated until midsummer and mulched the remainder of the season.

18. Soil moisture is conserved by plowing, which loosens the soil to the depth of several inches; by cultivating between the rows, which keeps loose the upper two inches of soil; by mulching which allows the rain to penetrate the soil but not leave it; and by having the plowed furrow slice cleanly fallow all or part of the year, thus avoiding the draft of growing plants on the soil moisture. It is dissipated by growing crops which pump into the air enormous amounts of water; by weeds which are perniciously active pumps in proportion to the useless growth they make, and by leaving the soil compact, allowing capillary water to rise to the surface there to evaporate. Soil water is precious in a droughty location and weeds are the poor farmers most expensive "lazy man's luxury."

19. Timothy, seven pounds; red clover, six pounds; and brome grass, four pounds, is the empirical formula now chosen for grass to lie two to three years in the rotation in southwestern Minnesota; while to lie three to five years the following is chosen: Timothy, seven pounds; red clover, six pounds; brome grass, ten pounds. But the shorter rotation is preferred, oftener using grass to prepare the land for other crops and securing the best crops of forage while the grass sod is young.

20. For rough, untillable lands the following mixture is recommended for permanent pasture: Red clover, three pounds; white clover, one pound; timothy, five pounds; brome grass, four pounds; Kentucky blue grass, four pounds. On pastures with sod of native grass, sow only half the full amount. Keep all coarse weeds mowed down in all pastures, as they waste moisture. Where practicable, every other year tear the sod with a disk in early spring and sow a mixture of four pounds red clover, one pound white clover and four pounds timothy; or, instead of first disking,

seed with disk drill, mixing grass seed with two pecks oats per acre to make the grass seed run evenly out of the seed box and to furnish oat pasturage.

21. For peaty and low lands desired for continuous meadows the following mixture is suggested: Timothy, seven pounds; alsike clover, two pounds; red clover, two pounds; and where wet, also, red top (solid seed), three pounds per acre. These lands pay best if well drained and used for crops in rotation. Where this is not practicable, sow with disk drill every other year among the grass the following: Red clover, three pounds; alsike, two pounds,—smoothing the land with the harrow after the drill, if necessary. If blue grass gets a hold in the hay land, plow after haying, raise one or two crops, as of fodder corn, then a crop of flax or grain with which to again seed the land, leaving the sod only as long as it yields heavily.

22. Preliminary experiments showed that a succession of annual pastures fed off by steers was most valuable to provide succulent food for cattle, especially in midsummer when the wild pastures and those in rotation with other crops are dry; and this treatment of the land provided unusually good conditions for the succeeding crop. After much experimenting a thoroughly practical method of conducting these pasture experiments has been devised and is being used at the several experiment farms.

23. The following plans for supplementing the rotation and permanent pasture for sheep give a good supply of foods very early; during the dry midsummer; and again very late in the fall: (a) Winter rye, followed by corn drilled 60 pounds per acre and cultivated, pastured at two feet high, and, where practicable, followed with rape. (b) Winter rye, followed by rape, 1 to 1½ pounds per acre, in drills and cultivated. (c) Winter rye, followed by sorghum drilled at the rate of 20 pounds per acre, cultivated until two feet high, and fed off; allowed to sprout up a second time and again fed off. (d) Oats and peas sowed very early, 1½ bus.

each per acre, and fed off from the time of heading until ripening, leave land fallow for the succeeding crop. This adds nitrogen and humus to the soil and conserves the rainfall of autumn for the succeeding crop. (e) Utilize any crops rendered very poor (as by hail or drought), by pasturing to sheep before plowing; thus aiding the sheep to do well in midsummer and securing finer conditions of soil for the succeeding crop than by harvesting a profitless, weedy crop, and thus, by allowing weed seeds to ripen, placing a heavy natural mortgage on the next year's yields.

The lack of faith in sheep among the farmers of the middle west, as shown by the small numbers kept, is not fully justified. These animals, by ridding the farm of weeds which would consume immense quantities of water, and by requiring cultivated pasture crops and rotation pasture and meadow crops, do a great service in preparing the soil for crops of grain and forage, for which they have been given only partial credit. All classes of live stock are mighty factors in field management, lessening weeds and greatly increasing the yields of all crops. Sheep are easily chieftest of all classes of stock as aids in the eradication of weeds, in conserving soil moisture, and in building up the fertility of the soils in our fields.

24. That shelter belts can be grown more rapidly, more easily, and of far greater utility and beauty than most people living in south-western Minnesota believe, is admitted by every one who inspects the experiments in grove-making at Coteau Farm.

25. A new series of plot experiments dealing with many of the questions mentioned above is under way. The main effort is to find which crops best prepare the land for each other crop, so as to determine in what order of succession the best paying crops should follow in the rotation, and what combinations of crops best serve the farmer with given conditions of climate, soil, stock, labor, etc. Mr. Gregg is dividing his large farm by permanent fences into 15 or more

fields, and a plan for farming each of these is nearly completed. The main products are sheep pasturage; grain for feed and sale; and cured roughage for a large flock of sheep and for a herd of dairy cows.

The Northwest Experiment Farm of the University of Minnesota was provided for by the legislature of 1895. The site was chosen by the agricultural committee of the board of regents, and Prof. Hays, who had made a study of the agricultural conditions of the northern half of the state. This farm is located a mile north of Crookston, and consists of 480 acres of nearly level land, similar to much of the land of the valley of the Red River of the North. The farm was donated to the Experiment Station for experimental purposes by President J. J. Hill, of the Great Northern Railroad. The city of Crookston and the county of Polk added to this magnificent gift the sum of \$2,000, to aid in draining and developing the farm, most of which was flat and subject to flooding by water from adjoining lands. The board of regents approved of the selection, and in June, 1895, the state acquired title to the property, and work was begun early in July. Mr. T. A. Hoverstad, a graduate of the School and College of Agriculture, was placed in charge of the work.

The only cultivated land in the tract was about fifty acres, which had been broken, cropped and filled with mustard and other weeds by trespassers. More land, aggregating at present 300 acres, was broken, pastures were fenced, roads and drains were made, buildings erected, and a fair amount of modern farm machinery was secured, in part by donation from manufacturers.

In the spring of 1896 the rainfall was so constant and excessive that the season for planting grain crops had practically passed before the seed could be planted. The experiments with varieties of field crops, with methods of cultivation, and with the forestry and horticultural crops were sadly interfered with by this excessive rainfall. On the other hand, the grasses

and clovers which were planted to produce pastures and meadows made most excellent growth, demonstrating that in seasons too wet for grain the grasses for live stock food will thrive. The fact that diversified farming results in some good crops during the years which may prove entirely disastrous to the grain farmer was demonstrated by the adverse conditions.

The wet springtime likewise proved disastrous to part of the horticultural and forestry plantations. In 1897 the fields were in fine condition, the absence of crops the previous season having resulted in much of the land being summer fallowed. All crops were successfully grown until nearly time for grain harvest, when excessive summer rains nearly ruined the wheat and oats. These moist years gave excellent conditions for grass and other forage crops, and good stands of experimental meadow and pasturage, so successfully started the previous year, made fine yields of forage, as shown by the reports embodied in this bulletin prepared by Superintendent Hoverstad.

To the other disasters was added the destruction by fire, caused by lightning, of the barn, with several horses and a larger part of the collection of farm tools and conveyances, the total loss being about \$6,000. Plans somewhat similar to those used in building the first barn were quickly made, and a new barn was constructed for the \$3,000 received from the St. Paul Fire & Marine Insurance Company on the one destroyed.

The experimental results for 1897 were better than those for 1896, but between the rain and the fire their value was greatly lessened. The forestry and garden trials were satisfactory, and the crops of hay, pasturage, etc., were excellent. In 1898 and 1899 the farm was more prosperous than in previous years, and the work is now at least fairly inaugurated.

In co-operation with Prof. Hays, Superintendent Hoverstad is experimenting with crop rotations and methods of farm management, testing varieties of wheat, oats, barley, flax and grasses. He is becoming acquainted with the people of the northwestern part of the state, who are alive to new methods,

and has been in demand for addresses. He has also written several articles for the press on Red River Valley farming. His experiments relating to the protection of the farm home by forests, how to grow vegetables and small fruits, how to manage stock,—all under the conditions of the wind-swept, level prairies of the Red River Valley,—are making him a valuable teacher of farm operations.

More money is needed for buildings, drainage, fencing and good specimens of live stock, and especially to pay for experiments in the fields. While there is an income from the sale of farm products, this cannot be sufficient to carry on experiments which ought to be undertaken in the interest of the farmers of the Red River Valley. Farm experimentation, like the invention and perfection of machinery, requires money to pay for things which prove failures as well as for those that prove of value.

Mr. Hoverstad is anxious to be in communication and close touch with those who are in need of assistance in their agricultural pursuits. Better service can be rendered to those for whose benefit the station was established, and it will also be helpful in planning experiments. The closer the union between the farmer and the Experiment Farm, the more valuable work will be done. Visits to the farm are most cordially invited at all times.

WILLIAM M. LIGGETT,
Director.

NORTHWEST EXPERIMENT FARM.

T. A. HOVERSTAD.

It is the intention of the Northwest Experiment Farm to publish from time to time reports showing the results of the experiments there and the progress of the work. In publishing this, the first, report, we are conscious of the fact that many of the results published will not be final, but are likely to be modified as new conditions in future years may influence them.

The agricultural conditions of the Red River Valley are peculiar, and differ from those of any other portion of the state. The soil is of exceptional fertility. The surface is an alluvium deposit, with a subsoil of clay that is almost impervious to water. In most places there is very little sand. The soil is capable of retaining moisture to a remarkable degree if properly cultivated. The land is very level, the fall being from a few inches to a few feet per mile, and natural drainage is not the best. However, artificial surface draining may be cheaply provided, so that at least the surface water may be rapidly carried away. A careful plan of drainage has been devised, and experiments have proven the plan practical. The completion of this drainage system will probably go further than anything else towards developing the country and putting agriculture on a safe basis. The soil is capable of producing a great variety of products, and of very high quality. Vegetables, grains, forage crops, grasses, roots, small fruits, some tree fruits, forest trees, shrubs, and flowers can be grown in great abundance. For some crops, like corn, melons, etc., the season is somewhat short, but during the growing season plant growth is very rapid. This is probably due to the very long days during the summer season. The

rapid plant development largely compensates for the shorter seasons. The climate is healthful and invigorating. The sky is clear most of the time, so that crops are easily cured. The ease with which a field could be worked, the fact that good crops were very sure while the land was new, prices high, and ready market at hand, early developed the single-crop system throughout the valley.

To criticise the present practice would be unjust. Many could not have done otherwise. A large majority of the farmers have done exceedingly well under the circumstances. A wise plan for the farmer is to continue in the practice which has proven a success with him. Changes from one system of farming to another should be gradual. The time is probably now ripe for a gradual deviation from the single-crop system to one more varied. The change should begin by introducing live stock. This is the most natural starting point, and the safest. The time required to change from wheat growing to live stock farming depends on one's means and one's skill as a stockman. If a man has both money and experience, buying the live stock immediately and commencing to feed need not occupy much time. If the money is not at hand and the experience limited, he must go slowly. He should begin with the stock which requires the least capital to purchase. Commencing with poultry, it will not take long to gather a large flock. They can be supported largely on the by-products which might otherwise be wasted. They will help to save very much of the outlay that formerly went to the grocer and butcher.

A flock of sheep can be purchased for a small expenditure. They will make good use of the very cheap foods on the farm, and often destroy harmful weeds. They will decrease the cost of living, and will help to produce money for the further extension of the live stock business.

The same principal facts are true to some extent in regard to swine: To commence with cattle, more capital is required, and the progress is not so rapid. By "growing" into the business, instead of "going" into it, the farmer will learn the care

and management while the herds and flocks are being built up.

The subject of shelter is a great problem in a new country. Good barns are expensive and few farmers can afford to erect the buildings they would like to have. Stables for shelter, to be used only for a few years, need not be costly. Walls made of two thicknesses of cheap boards, packed with hay, flax straw, or other cheap material, can be made warm. Poles may be substituted for the boards, but the walls must then be made thicker. The roof can be made of straw, thatched with rye straw or marsh hay, provided enough material is put on to keep the heat from escaping. Such shelter is the only one used on the Experiment Farm at the present time for cattle, sheep and poultry. These cheap barns can be made light, warm, dry, and well ventilated. There is nothing in the way of comfort for the animals that cannot be provided in these barns. They cannot always be made models of convenience, and their appearance may not be in their favor in comparison with frame barns.

The farm being stocked, the change in crops must follow. Pastures must be provided. A part of the land must be set aside for meadow to produce hay for winter feeding. A greater variety of grain must be grown. Corn for fodder and for grain should be raised as an economical feed for all classes of cattle and horses. This will necessitate the cultivation of a part of the land, thereby reducing the number of weeds and improving the soil. This rotation of grains, grasses, and cultivated crops in connection with the live stock is the safest system for the farmers of the Red River Valley to adopt. By this system the fertility of the land is not exhausted, the weeds are kept in check, a larger variety of crops is raised, and the farmer assumes less risk. The extreme high wages at one season, and the inability to furnish employment at another, would thus be avoided. This will help to destroy a system which is undesirable to both employer and employed, and certainly very demoralizing to the employes of the country. The migratory laborer would be replaced by the permanent one, who would make his home in one place rather than change it with the seasons.

Another thing that must not be overlooked is the farm operations. The farmstead must be beautified and made to bring comfort as well as financial returns. Vegetables can be made to grow in abundance, and of excellent quality. Small fruit can, with some care, be made to produce good crops. These can be grown cheaply, and need occupy only a very small area of ground. A better table and the reduction of living expenses fully justify both the vegetable and small fruit gardens. There are enough hardy trees, shrubs, flowers, etc., from which to select for protection against storms and for ornamenting the home. To make the home comfortable, pleasant, and beautiful is one of the first thoughts that should occupy the mind of the farmer.

FIELD CROPS.

The effort at Northwest Experiment Farm is to secure the best available varieties of the different grain and forage crops. This work is done in co-operation with Prof. W. M. Hays, who supplies from University Farm the varieties which there prove best among very large numbers secured from all parts of the world, or originated in his extensive breeding experiments. He is co-operating with the National Department of Agriculture in introducing into Minnesota grain and forage crops from similar climates in foreign countries, and has inaugurated a general method of distributing them, and also those originated by the Experiment Station, to the farmers of the state. The work already done with wheat, corn, oats, barley, flax, field peas, timothy, bromus, and other plants leads to the belief that much good will come to this valley, as well as other parts of the state, from this work of introducing and breeding better varieties of our staple crops. This experiment farm will naturally take a prominent part in the effort to find which of these varieties is best suited to the conditions of Red River Valley farms. In some cases, as with varieties of corn and some of the new grasses, part of the breeding must be done here, to adapt the varieties to the conditions of climate, soils, and the methods of

farming practiced here. Limited quantities of a few of the more promising varieties of grains have been sold from Northwest Experiment Farm, though raising seeds on land subject to flooding is by no means an easy undertaking, since the seeds of varieties are floated from one field to another. When the larger drains are completed this difficulty will be surmounted.

The Experiment Station has adopted the plan of using numbers for designating all stocks of field crops which it introduces or originates on any of the several experiment farms. Newly originated varieties have no names other than the numbers, which are written as follows: "Minn. No. 163 Wheat;" "Minn. No. 13 Corn;" etc.

In this report the yields only are given. For the history and general characteristics of the varieties mentioned in the following tables, the reader is referred to Minn. Bulletins Nos. 40, 46, 50 and 62. The yields so far have been abnormally low, because of unusually wet years and a lack of drainage. In 1899 a hailstorm also materially lowered the yields.

Wheat is used on this farm as the standard crop with which to compare other crops and rotations and to test the condition of the soil under various methods of treatment, such as plowing, tillage, crop rotations, etc. While the formal rotation experiments have not yet reached the stage for report, yet the very great importance of grasses and cultivated crops in the rotation to increase the yields of wheat and other grains is clearly shown. Live stock to use the forage and part of the grains and by-products to advantage is shown to be most important. Since live stock is the only means of reducing grass and cultivated crops to a marketable form, they are very valuable on the grain farm to permit the rotations with grasses needed by the wheat.

WHEAT.

In tables I. and II. will be found the yields of wheat. Out of forty-four varieties tested only the eleven in Table II. are now retained.

TABLE I.—Wheat Variety Tests, Two Years.

Minn. No.	Variety	Yield in '97	Yield in '98	Yield in '99	Average Yield
66	Power's Fife.....	8.4	18.1	.....	13.2
105	Glyndon 711.....	14.8	15.1	.....	14.9
149	New.....	20.7	18.9	.....	19.8
155	New.....	18.8	19.9	.....	19.3
157	New.....	23.0	20.1	.....	21.5
185	Advance.....	10.8	16.0	.....	13.4
188	Preston.....	20.0	19.3	.....	19.6

Minn. Nos. 163 and 165 have been sold to some extent for seed. These have proven to be good yielders, produce flour of good quality, ordinarily do not lodge, do not shell out easily, and withstand plant disease as well as any known varieties. The yield for 1898 is the average of two trials on different fields. One and one-eighth bushels per acre have been sown with shoe drills each year.

TABLE II.—Wheat Variety Tests, Three Years.

Minn. No.	Variety	Yield in '97	Yield in '98	Yield in '99	Average Yield
163	New.....	28.3	21.4	13.2	20.9
165	Wellman's Fife.....	20.2	25.5	15.6	20.4
167	New.....	19.7	26.2	9.5	18.4
169	New.....	17.8	22.5	10.8	17.0
171	New.....	11.8	24.5	12.0	16.1
172	New.....	18.3	26.8	13.3	19.4
181	New.....	26.3	21.5	13.8	20.5
294	New.....	19.0	23.9	10.2	17.7
295	Blue Stem from C. E. Jackson.....	17.0	26.4	10.3	17.9
457	Buchanan.....	23.0	20.9	9.0	17.6
458	Egyptian Fife.....	19.7	23.8	11.8	18.4

OATS.

Twenty-five varieties of oats have been tried during the past three years, and their yields are tabulated in Tables III. and IV. Two bushels per acre have been sown with the shoe drill. Minn. Nos. 35 and 230 have been raised in large quantities for feed and seed, and have proven very satisfactory. No. 26 has proven a very good yielder at several stations, and it is the intention to increase the supply so it can be sold for seed. Minn. No. 196 matured nearly two weeks earlier than the rest, but was discarded owing to poor yield and inferior quality. All the varieties retained have shown marked power of rust resistance during the past three seasons. So long as oats remain such a valuable article for food, they are likely to be one of our important crops. No crop was raised in 1896, owing to the excessive rains in early spring.

TABLE III.—Oats Variety Tests, Two Years.

Minn. No.	Variety	Yield in '97	Yield in '98	Yield in '99	Average Yield
4	Early Swedish.....	44.4	.....	.....	44.4
80	Imp. White Russian.....	46.6	.....	.....	46.6
192	.....	50.3	.....	.....	50.3
193	.....	57.5	.....	.....	57.5
194	.....	51.6	.....	.....	51.6
195	.....	41.6	.....	.....	41.6
197	.....	57.5	.....	.....	57.5
198	.....	55.0	.....	.....	55.0
199	.....	47.2	.....	.....	47.2
200	.....	30.8	.....	.....	30.8
201	.....	32.8	.....	.....	32.8
209	.....	.....	49.4	.....	49.4
211	.....	.....	42.9	.....	42.9
36	Giant Side.....	45.6	57.9	.....	51.7
196	.....	48.1	40.6	.....	44.3
230	Red River Oats.....	62.9	58.4	.....	48.8

TABLE IV.—Oats Variety Tests, Three Trials.

Mean No.	Variety	Yield in '97	Yield in '98	Yield in '99	Average Yield
6	Improved Ligowa.....	57.9	58.4	38.3	51.5
28	Lincoln.....	59.1	69.2	41.9	56.7
26	Early Gothland.....	75.6	66.7	42.0	61.4
29	Archangel.....	47.6	60.9	40.2	49.5
32	White Wonder.....	62.2	61.8	44.7	56.2
35	.....	61.9	62.8	38.4	54.3
64	Black Russian.....	62.2	65.6	45.9	57.9
190	.....	93.1	61.5	43.8	66.1
191	.....	32.8	63.1	45.3	47.1

BARLEY.

The necessity of growing barley in a country where corn matures with uncertainty is manifest. It is also a valuable grain in seasons when early spring rains delay seeding until it is too late for sowing wheat.

Table No. V. shows the yield of the barley raised during the past two seasons. The crop of 1899 was sown in duplicate, so the yield reported is the average of two trials. This crop was very seriously damaged by hail, as it was nearly mature when the storm occurred. How much damage was done cannot be estimated. It seemed, however, that all the varieties were injured alike, so the yields are considered comparable. Several varieties of barley were sown in 1896 and 1897, but owing to the heavy rains they were injured so seriously that no record of any value could be reported.

TABLE V.—Barley Variety Tests, Two Years.

Minn. No.	Variety	Yield in '98	Yield in '99	Average Yield	No. of Trials
6	Manshury.....	40.4	15.3	27.8	2
7	Champion of Vermont.....	36.2	20.7	28.4	2
15	French Chevallier.....	37.1	21.8	29.2	2
21	Odessa.....	36.2	22.6	29.4	2
28	Barnard's.....	34.8	20.7	27.7	2
86	Culver.....	32.9	20.8	26.6	2
100	Golden Queen.....	42.1	21.4	31.7	2

FLAX.

Efforts at testing varieties of flax have been so unsatisfactory that no tabulated results of yields can be offered. Flax is very sensitive to alkali in the soil, and, the field used in 1898 being slightly spotted with alkali, the yields of the adjacent plots of varieties were not comparable. Fields of flax have been successfully grown on freshly broken soil. Since flax is less affected by the time of sowing than other grain crops, it may sometimes be sown when rains or other causes make it impracticable to plant wheat or oats in seasonable time. Harvesting has been found most satisfactory when a platform is built on the harvester, in place of the binder. The flax can then be thrown off in windrows, with the heads all outward and upward. Flax straw will doubtless prove to be more valuable in the future than it now is. It is valuable for feed, can be utilized in a variety of ways on the farm, and there is a growing prospect that the immense quantities of flax straw now annually wasted will be used for making fiber, paper and other products.

BUCKWHEAT.

Buckwheat has been sown twice, and has grown well, producing an undue proportion of straw,—a usual result elsewhere on rich soils. If this crop can be raised here for seed, so

that home-grown seed will be available, buckwheat promises to be of value to use as a green manure crop and to aid in killing mustard and other weeds. When planted after a first plowing in the summer fallow year, and turned under two months later, it will not only manure the land, but its rapid and thick growth will greatly aid in smothering weeds. A small plot raised for poultry and fed out in the bundle answered a very good purpose.

GRASSES AND CLOVERS.

The native grasses have never given very satisfactory results on Northwest Experiment Farm. The pasture has supported only a small amount of stock per acre. Estimating the yield of dried hay during the last four years would place it at half or three-quarters of a ton per acre. This is less than the rich lands in the Red River Valley should produce.

There are two ways of increasing the yield on prairie land: (1) By improving the growth of the native grasses; and (2) by breaking up the sod of native grasses and introducing other species that are more promising. The native prairie grasses are valuable for feed, and the nutritive quality is good, but the yield is too low. Top dressing native grass land has been tried, but this is impracticable at present, owing to the large area to be fertilized and the small amount of available manure. A better way is to break up the land and introduce new and more productive species in the crop rotation.

Experiments were begun early (1) to test new species and varieties of grasses and clover, to determine their adaptability to the Red River Valley, to ascertain their yields, and to determine their nutritive quality and longevity; (2) to learn the best methods for their management and find their place in the rotation.

The first seeding was done on June 20, 1896, when thirteen varieties were sown broadcast on one-fifth acre plots without nurse crops. The same experiment was repeated, with some

changes, in 1898. The yields are recorded in Table VI. The winter of 1896-97 was particularly favorable for the wintering of grasses and clovers, while the winter of 1898-99 was quite severe, though the wet fall of 1898 put them into the winter in good condition. It will be noticed that in both trials the



Fig. 1.—Slender Wheat Grass.

clovers have wintered well. Red Top, Brome grass (*Bromus inermis*), Slender Wheat grass (*Agropyrum tenerum*), and timothy all yielded well, and have proven very worthy of extended trials. Kentucky Blue grass was sown on a few plots.

It formed a very thick sod, and would doubtless prove valuable for pasture in seasons with sufficient rainfall, but in dry years its yield is light. Bokhara is valued elsewhere for green manure, and for this purpose it may prove an important crop here, as it produces a large growth. Meadow Fescue yielded well in 1896, but was very seriously damaged the following winter. Fowl Meadow grass was sown, but failed to endure the winter. White clover formed a good sod the first year, but the plot has since been taken possession of by timothy and clover from the adjoining plots. *Muhlenbergia racemosa* and *M. pringlii* were sown, but failed to make a good stand of plants. Doubtless these two last-named grasses will grow better when more attention is given them, as they grow well here in the wild state.

TABLE VI.—Test of Varieties of Grasses.

Variety	Seed Per Acre Lbs.	Yield in '97	Yield in 1899	
			No Nurse Crop	With Nurse Crop.
Common Red Clover.....	7	2485	2872	4862
Mammoth Red Clover.....	7	5070	5195	4752
Alsike Clover.....	4	2609		
<i>Bromus Inermis</i>	20		3300	4025
<i>Agropyrum Tenuum</i>	20		3975	4715
Timothy.....	10	2982	3765	3750
Red Top.....	5	3032	4450	4975
Alfalfa.....	10	1200		
Meadow Fescue.....	20			2400
Orchard Grass.....	20			2340
Canadian Blue Grass.....	20			3965
Bokhara.....	8	3006		

BROME GRASS.

(*Bromus Inermis* Fig. 2.)

The most promising permanent grass so far tested is *Bromus inermis*, commonly called "Brome Grass." It is the first to start in the spring among all the grasses tried. It is usually

ready for pasturage about three weeks before the native grasses. It will also keep green a long time after the native grass is withered in the fall. It yields well on drained land, and, so far, has been uninjured by our coldest winters. It can be pastured close in the fall, as it needs no winter protection. The seed can be sown at almost any time during the summer. Our experience is in favor of spring or early summer sowing.



Fig. 2.—Brome Grass.

In Table VII. are recorded the yields when sown with and without nurse crops. The results are in favor of no nurse crops.

The yields recorded are all small. This is due to lack of drainage on the land where it was grown. On spots where drainage was good the yield was very high. Where the land was flooded for some time in the spring, it was very poor. On land poorly



Fig. 8.—*Bromus*.

drained there may be grasses that will yield better. It is recommended for permanent meadows and pastures as the whole crop or at least a part of the grass mixture.

TABLE XI.—Nurse Crops for Brome Grass.

Nurse Crop	Rate Sown	Yield
No Crop.....	.....	2101
Barley.....	48 lbs.	1197
Flax.....	28 "	1275
Oats.....	16 "	1519

CLOVER.

There is no crop more needed in the Red River Valley than clover. There seems to be a prevalent idea that clover will not grow here. In all the trials conducted on this farm there has been manifest evidence that clover will not only grow, but grow well. In twenty trials conducted here, common red clover has given an average yield of 3,714 pounds per acre. The lowest yield recorded is 1,955 pounds, and the highest, 6,025 pounds. The mammoth clover has in five trials yielded an average of 4,904 pounds per acre. These yields have all been produced under the ordinary system of farming. No special care was given to any of them.

TABLE VIII.—Different Nurse Crops for Mammoth Clover.

Nurse Crop	Rate Sown	Yield
No Crop.....	.....	5132
Wheat.....	45 lbs.	3755
Oats.....	32 "	3750
Barley.....	48 "	4752

The experience so far indicates that it is wise (1) to sow only good clean seed; (2) to sow it in the spring with the grain crop at the rate of twelve to fifteen pounds per acre; (3) to sow it with a nurse crop that does not shade the ground too much; (4) to cut the nurse crop so that a long stubble will be left to catch the snow during the first winter.

A good crop cannot be expected more than one season, as the clover is only a biennial, after which the land must be plowed and used for grain. When the land becomes older, and clover has been raised on the fields, a smaller amount per acre should be sown. In the trials comparing drilling and broadcasting, the balance is slightly in favor of the broadcasting. It will be remembered that in both 1896 and 1898 there was enough rain to give the clover a good start. The broadcasted plots were thoroughly harrowed, so the seed was well mixed with the soil.



Fig. 4.—Clover.

The plan now practiced on Northwest Experiment Farm is to sow the grain the usual way; then sow the clover seed with the grain drill at right angles to the way the grain was sown. The clover seed is sown slightly more shallow than the grain. If the drill is not adapted to sowing the grass seed sufficiently thin, a few quarts of the grain may be retained and mixed with the grass seed, to aid in regulating the thickness.

TABLE IX.—Common Red Clover, Drilling vs. Broadcasting.

Nurse Crop	Rate Sown	Drilled	Broadcasted
No Crop.....		3790	1955
Wheat.....	25 lbs.	5350	3215
“	50 “	3665	3450
“	75 “	2800	2875
Oats.....	50 “	3940	3575
Barley.....	40 “	4200	5525
Flax.....	35 “	2765	5085
Millet.....	25 “	2215	3640
Average.....		3591	3665

THICKNESS OF NURSE CROP FOR CLOVER.

In Table No. X. is recorded the result of an experiment in sowing different amounts per acre of the nurse crop. A crop sown in a field on June 8, 1898, yielded 6,025 pounds of hay in 1899. The weeds were cut at different times during the season, and in the fall enough clover was allowed to grow up to furnish its own protection. While a good yield was obtained in 1899, there was no return from the land in 1898, which might have been obtained had a nurse crop been sown.

TABLE X.—Thickness of Seeding Nurse Crop for Clover.

Nurse Crop	Rate Sown	Yield
Wheat.....	25 lbs.	4282
“	50 “	3557
“	75 “	2837
No Crop.....	.....	2872

From Table XIII. it will be seen that barley was the best nurse crop. In Table XI. the yields of Brome grass when sown with nurse crops are recorded. The plots, however, were so often flooded by water that it is difficult to estimate the influence on each plot. The main value lies in showing the higher yield where no nurse crop was sown. The record of the yield where no nurse crop was sown is the average of the two sowings.

TABLE VII.—Different Nurse Crops for Clover.

Nurse Crop	Rate Sown	Yield
No Crop.....	.....	2872
Wheat.....	50 lbs.	3559
Oats.....	50 “	3757
Barley.....	40 “	4862
Flax.....	35 “	3925
Millet.....	25 “	2927

TABLE XII.—Grasses—Mixtures for Meadows.

Grasses	Lbs.	Yield	Proportion of each Variety		
			1897	1898	1899
Timothy.....	8	2400	Per cent. 40	Per cent. 95	Per cent. 85
Red Clover.....	6		60	5	15
Timothy.....	8	2275	35	85	95
Mammoth Clover.....	4		65	15	5
Timothy.....	8	2350	35	80	40
Alsike.....	3		65	20	60
Timothy.....	4	1825	40	95	40
Bokhara.....	4		60	5	60
Timothy.....	3	1875	15	94	85
Mammoth Clover.....	2		45	1	5
Red Clover.....	3		40	5	10
Timothy.....	8	1775	25	95	90
Alsike.....	3		15	3	5
Red Clover.....	3		60	2	5
Timothy.....	3	2075	10	88	40
Bromus.....	8		5	10	55
Red Clover.....	8		85	2	5
Timothy.....	3	1500	40	25	30
Bromus.....	8		40	70	60
Alsike.....	2		20	5	30
Timothy.....	5	1000	50	85	85
Kentucky Blue Grass.....	4		10	10	5
White Clover.....	4		40	5	10
Timothy.....	2	1525	50	75	40
Bromus.....	2		10	20	55
White Clover.....	4		35	0	0
Kentucky Blue Grass.....	2		5	10	5
Timothy.....	5	1375	75	65	40
Bromus.....	8		20	30	60
Blue Grass.....	5		5	5	0
Timothy.....	5	1575	100	100	100
Meadow Fescue.....	5		0	0	0
Timothy.....	5	1300	20	95	100
Meadow Fescue.....	3		0	0	0
Red Top.....	3		80	5	0

SOME 1899 RESULTS.

Red Clover.....	5	5260	.....	.....	.....
Alsike.....	3		.....	.....	.....
Red Clover.....	5	5515	.....	.....	.....
Mammoth Clover.....	5		.....	.....	.....
Red Clover.....	8	3425	.....	.....	.....
Timothy.....	6		.....	.....	.....

GRASS MIXTURES.

Thirteen grass mixtures were sown in June, 1896. The yields are reported in Table XII. Three mixtures were sown in 1898, which are recorded in the same table. The yields are comparatively low, except those of 1899. It will be noticed in columns 4, 5, and 6 that the percentage of clover was less in 1898 than in 1897, but improved again in 1899. Clover has

also spread out on adjoining plots. While the percentage in the table shows an increase in the timothy, it is not due to any improvement of the timothy, but to the reduction of the other grasses in the mixture. *Bromus inermis* has in nearly all cases improved since it was sown. The results in the case of clover warrant keeping the land in clover only one year following the year of seeding.

TABLE XIII.—Testing Various Nurse Crops for Timothy and Clover.

Nurse Crop	Rate Sown Lbs.	Yield Per Acre	Grass	Rate Per Acre	Per cent. in '97	Per cent. in '98	Per cent. in '99
			Clov.	6	Clov. 50	Clov. 5	Clov. 15
Oats.....	45	1975	Tim.	8	Tim. 50	Tim. 95	Tim. 85
Barley.....	35	2050	"	8	{ " 40 60 }	" 95	" 85
Wheat.....	45	1850	"	8	{ " 40 60 }	" 95	" 85
Millet.....	30	1425	"	8	{ " 40 60 }	" 95	" 85
No Crop.....		2400	"	8	" 60	" 95	" 85

CULTIVATED AND FORAGE CROPS.

Several cultivated and annual forage crops have been tried each year. These crops are valuable when livestock is introduced, and for cleaning the land of weed seeds. Much valuable food can be obtained by these crops, and they are most excellent to prepare the soil for grain.

CORN.

Corn is the most important annual forage crop so far tried. During each of the past three years several of the best obtainable varieties have been planted. The object was to test the length of time it takes each to mature for fodder, and also their ability to produce fodder, both as to quality and quantity. The land being very wet each year during the planting season, the

sowing of the seed has been postponed until June. While no varieties have matured ears, many have nearly done so. In case the seed could have been sown in season, doubtless several of these varieties would have matured. Many of them produced a large yield of fodder corn. The yields this year with single rows 42 inches apart averaged four to six tons air-dried fodder per acre. By heavier seeding the yield could have been greatly increased. In Table XIV. are given the results for 1898 and 1899. It will be noticed that many of the varieties were nearly ripe at harvest, 100 per cent. representing matured corn. The seed for fodder corn in northern Minnesota will for a while have to be bought. Meanwhile it will be wise for the farmers to try to secure corn that will mature early and at the same time produce a good yield of fodder. A plot for seed can be planted in the garden, and so long as maturing is so uncertain this planting should be confined to a small area. Corn fodder is valuable for all classes of livestock, horses included. It will be wise to raise this valuable fodder plant much more extensively.

TABLE XIV.—Variety Test of Corn for Fodder.

VARIETY	1898			1899		
	Height of Stalk	Fodder	Per Cent. Mature	Height of Stalk	Fodder	Per Cent. Mature
Squaw.....	6	60	10	4	50	80
Smut Nose.....	5	80	10	5½	80	95
Mercer.....	5	90	5	6	95	85
Longfellow.....	5½	85	20	4	65	70
Pride of the North.....	6	90	15	7	97	95
Giant Field.....	6½	75	25			
Portland Hybrid.....	4	75	20			
Minn. No. 159.....	3	40	10	2½	25	95
Lommen.....	4½	85	10	5	85	95
Twedden.....	4	80	5			
Minn. No. 13.....	7	95	15			
King Phillip.....				7	90	80
N. K. & Co. Dak. Dent.....				7	80	80
North Dakota White Flint.....				4½	75	95
Rustler.....				7	60	60
Big Squaw.....				5½	90	70
Early Johnson Dent.....				5	65	85
90 Day Flint.....				4	60	80
Half Dent.....				5	75	85
Minn. No. 169.....				7	100	85

RAPE.

For three seasons rape has been grown. The yield has in all cases been very good, excepting where alkali was in excess in the soil, or drainage was lacking. In one plot, where alkali injured the rape in spots in 1897, a good crop of rape was produced in 1898 by manuring the alkali spots with barnyard manure. The growth can be imagined from the appearance of Fig. 5. The photograph from which the figure was reproduced was taken late in October. No definite experiments have been conducted with it. One plot of three-

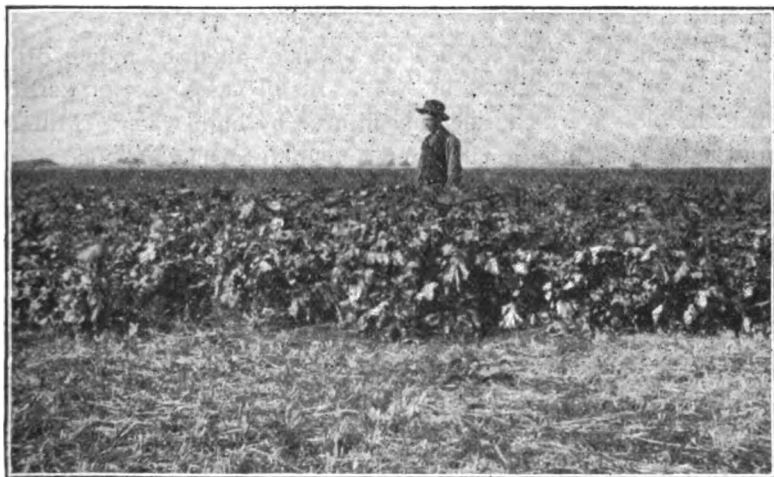


Fig. 5.—Rape Grown in 1898.

fifths of an acre was sown in 1898 beside a similar sized plot of sorghum. The sheep were pastured on these plots all summer, with good results. The rape may be sown any time from early spring to midsummer on any well drained, alkali-free soil. It will resist the frost in the fall much better than any other forage plant tried. These plots were sown broadcast, and in drills 30 inches apart. For pasturage, sowing broadcast or with the ordinary grain drill will prove satisfactory. Rape is very useful for sheep and hogs, is useful as a green manure crop in the year of fallow, and should be used extensively in the Red River Valley.

SORGHUM.

Sorghum has been grown during the past three years. In 1897 it averaged 4.4 tons air-dried fodder per acre, and in 1898, 4.8 tons per acre. It is grown in drills 42 inches apart. In 1898 a three-fifths acre field was sown to sorghum. This field was pastured to sheep during the summer, in alternation with a field of rape of similar size, proving very satisfactory. Sorghum is tender, and is killed by frost not severe enough to kill corn. It is valuable for a summer pasture only, while rape can be used for both summer and fall pasturing.

OTHER FORAGE CROPS.

In Table XV. are recorded the yields of air-dried fodder obtained from several crops in 1897. In all cases, except kaffir corn, the plots were considerably injured by high water. Millet is valuable to help clean the land and to furnish good food for the cattle. Other forage crops have been tried, yellow and white Milo maize, Pearl millet, Sand vetch and Teosinte, but none of these equal corn, and few mature seed. Corn, rape, sorghum, and millet, together with early-cut crops of the common spring grains, make a list of fodder crops large enough to meet the present needs of the Red River Valley farmer.

TABLE XV.—Cultivated Crops.

Plot	Name of Crop	Yield	Notes
1.....	Sorghum	8740	Injured by Water.
2.....	Hungarian Millet	3451	" " "
3.....	German Millet	5250	" " "
4.....	Hog Millet	2750	" " "
5.....	Dhoura	8050	" " "
6.....	Kaffir Corn	3000	Grows slowly first, better later.
7.....	Sand Vetch	.....	Good.
8.....	Pearl Millet	.....	Grew very well except where
9.....	Rape	.....	there was alkali in the soil.

While corn is the most valuable forage crop tried, peas and oats and sorghum and rape for summer pastures, and rape and cabbage for fall pastures, are very useful and worthy of extended trial.

CROP ROTATIONS.

Cropping fields continuously to spring grains eventually brings disaster. Crop rotation is being rapidly forced upon us by necessity. While the Red River Valley is admirably adapted to grain growing, we have a variety of grasses and cultivated crops which rest and prepare the soil for grain and may be profitably grown in alternation with the grains. Wheat, oats, flax, and barley form collectively only one of the three classes of crops to be provided for in the rotation. Timothy, Brome grass, the clovers and other grasses form a second class of crops. Corn, sorghum, millet and rape, and other cultivated and annual forage crops form the third class. Alternating the grain crops with each other is not worthy the name of rotation, because these crops, instead of preparing the land for each other, make it more weedy every year and less prepared for grain. Grain prepares the land for grass, serving, as it does, as a nurse crop with which to sow the grass during the first year when it is only starting its growth. The grass, after lying one or more years, has again prepared the land for grain. The grass also prepares the fields for corn, or other cultivated crops, and these in turn admirably fit it for other crops of grain. In a general way, we can have a rotation of grain followed by grass, and this followed by cultivated crops; then, returning to grain, again repeat the three-course rotation. Since the grass is usually left two or three years, this would not give a large enough acreage of grain, with all fields under the rotation, unless the grain also were grown for two or three years in succession, and this is often advisable while the land is new, weeds not too numerous, and there is not sufficient stock to utilize large quantities of roughage.

The following general plan will often be found useful: Grain one or two years, grass two or three years, grain two years, cultivated crops one, then returning to grain repeat the six-year rotation. The grain before the grass may be reduced to one year by seeding grass seed with the first crop of grain after the cultivated crop, thus making the grass period three

years. If the grass seeding fails to make a stand, which will occur occasionally, grain may be sown on the same field the second year, again seeding to grass, and thus reducing the grass period to two years.

The real starting point of a rotation is the introduction of live stock. The grasses and cultivated crops cannot well be marketed except they be first reduced by animals and condensed into live-stock products. And with the roughage must be fed part of the grain and the by-products of the grains, thus keeping on the farm much more of the fertility abundant in our soils, but not so inexhaustable as to warrant ruthless waste by shipping to our eastern or foreign competitors. Rotation of one grain with the others, without crops for live stock, is not true rotation.

At first a small amount of the farm may be included in the rotation. Later on other fields may be added, as the increase of live stock makes it practicable to do so. A plan of rotation should be adopted and then adhered to in a general way. In the year when grain occurs, that grain crop which promises the best returns may be selected, whether it be wheat, oats, flax, or barley. Attention should be given to the choice of a combination of crops which will best utilize the labor for the entire season, and will not too much congest the labor of busy seasons, as seedtime and harvest. Thus, for a five-year rotation of wheat, clover with timothy two years, flax and corn might suit many farmers, since these crops follow each other nicely, and provide a succession of work for men and teams. A system of experiments on crop rotation and field management has been begun at Northwest Experiment Farm, in co-operation with Prof. W. M. Hays at University Farm. In the spring of 1899 sixty plots were set aside for this purpose. A separate rotation is planned for each plot. In the effort to find how best to arrange the crop rotation for this district the crops each year are carefully measured and valued for market and feeding. The effect of each crop on the land is studied, and also its effect in making the land more or less weedy. Since

only one year's results are as yet available, no report can now be made. The North Dakota Experiment Station at Fargo has also in progress work on crop rotation and field management. Many farmers in the Red River Valley, likewise, are working out systems of field and farm management in a most practical way. These will all be constantly studied in connection with the experiments at Northwest Experiment Farm, as will also the past and current work in other states and in foreign countries. The facts, so far as available from all sources, warrant the following statements:

(1) Farmers in the valley very much underestimate the value in ultimate net profits of live stock and the crops necessary to feed them when grown in rotation.

(2) Cultivated crops and grass crops, as a rule, better prepare the land for grain than does the fallow, and in the end pay better if judiciously fed to live stock.

(3) Timothy and clover, if not at once, after a few trials are so successful as to be very useful in short rotations with wheat, flax, oats, and barley.

(4) Minnesota dent corn grown for fodder, when about one bushel of seed per acre is planted, is a very valuable hay crop, and admirably prepares the land for grain.

(5) Sorghum and rape are very useful on the land. Instead of leaving it fallow they make excellent pasturage, and put the soil in fine condition for grain.

(6) The variety of grain used counts for much in the yield, but the preparation of the soil by previous crops in the rotation means much more.

(7) The farm should be laid out with definite fields, and these should be enclosed with fences, some of which may be movable, and the crops rotated in regular and systematic order.

(8) Since stable manure often causes the grain to lodge on the very rich, moist soils of the Red River Valley, it should be (a) applied to the previous crop; (b) composted in level piles three feet high, so as not to fire-fang; (c) and always be ap-

plied thinly, about 10 two-horse loads per acre, so as to get the good effect without the over effect which causes the grain to lodge and not fill well.

(9) On farms where the rotation, manuring, and good cultivation of crops are properly combined and attended to, the strong growing crops help to smother the weeds, and even French weed, mustard, and wild oats lose their terrors.

(10) The business of live stock breeding and co-operative dairying in the Red River Valley needs organizing and promoting, in order that that most necessary element in our farm business—live stock production—may be encouraged, built up, and wonderfully developed.

DRAINAGE.

If there is anything that the Red River Valley is in need of to help eliminate the element of uncertainty in crop production, it is drainage. The growing season being very short, it is necessary that the water from melting snows and from storms be carried from the fields very rapidly in early spring. The soil is of a clayey nature, and of fine texture, so that the water percolates through it very slowly. The land is very level, having a fall of only a few inches or at most several feet per mile. The country near the eastern border, and also the land along the Red River of the North, is a little better drained than the middle section. Here the land is very level, and the storm waters from the east lose their channels and spread over the country, making large marshes. The water, after flowing very slowly over the prairie, again collects in channels and flows into the Red River of the North. The state, supplemented by private individuals, has given very liberal assistance in digging main channels to carry this water across the land. These channels have done an immense amount of good, and have contributed very largely to the prosperity of this section of the state. The amount of good resulting from this cannot be estimated. This work has been continued by the counties. The value of drainage has been so manifest, and it

necessity so apparent, that counties have found it wise to prosecute the work on a smaller scale when state aid was not available. Townships also have done a great deal of work in drainage.

Drainage and road building here on this level land go hand in hand. To make good roads it is necessary to construct high road grades. The making of these grades and the digging of large ditches are accomplished by the same operation. These ditches have been very effectual in draining the farms. They have been sufficiently numerous to be in close proximity to most fields. They might at times have been more effectual and often some labor might have been saved if they had been constructed according to a careful survey. Occasionally more good could have been accomplished if the labor expended on making a ditch on each side of the grade had been utilized in making only one. The road grade would have been equally well drained, and the deeper ditch would have drained the land better.

On most farms ditching is necessary in order to carry the water from the fields into the lateral and roadside ditches.

Two methods have been tried in the fields of Northwest Experiment Farm: One is to make shallow surface drains by means of the reversible road machine. These ditches are made easily and rapidly. They cannot be made very deep, and if they are put across a field they can be repaired frequently, as a good deal of material is carried into them by the plow, harrow and wind. There will necessarily be small ridges on each side of these ditches, so at intervals it will be necessary to cut openings through to admit the water. This plan may be modified by making two broad ditches twenty to thirty feet apart and throwing the earth up into a broad, flat, road-like ridge between, thus avoiding the slight ridge at the outer sides of the ditch. Into these ditches the broadened dead-furrows mentioned in the next paragraph may be made to enter, thus reaching all parts of the field with a system of broad, flat ditches through which the plow or reaper will pass and in the bottoms of which good crops may be sown. This latter method of making cross-field ditches is advantageous where the soil drifts

badly. By making the bottom of the two ditches a few feet further apart in cleaning them out with the reversible road machine there is room for throwing the dirt on the grade between without making it too high.

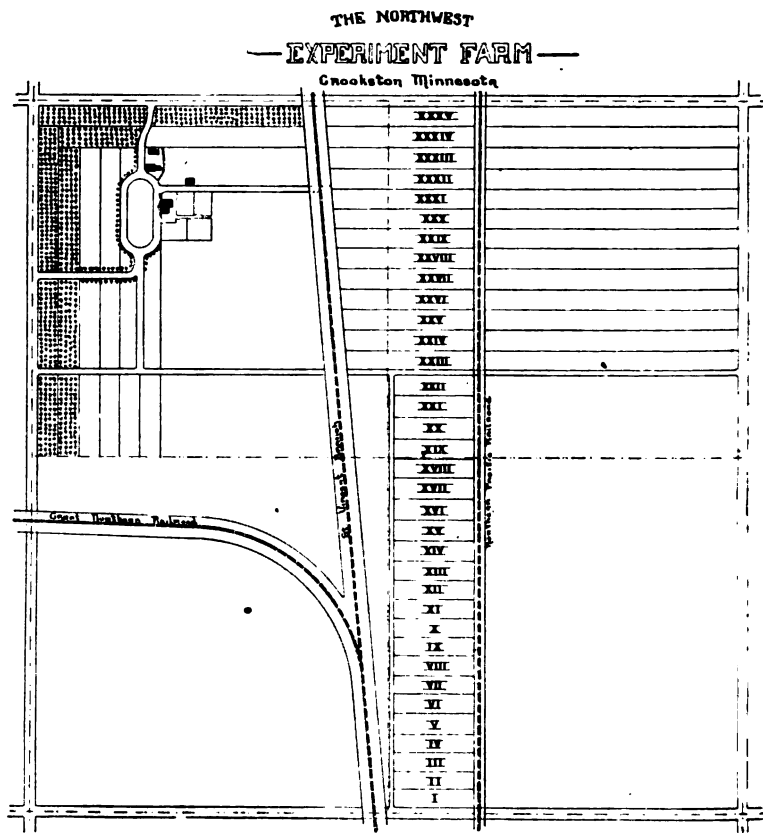


Fig. 6.—Plan of Farm.

Another method, which has proven very efficient and inexpensive, is ridging the land while plowing the fields. The Experiment Farm is laid out in fields or lands, each nine rods wide. (See Fig. 6.) These fields are laid out parallel with the slope of the land. The plowing is started in the middle of

the land (see Fig. 7), where two furrows are plowed against each other. By plowing in this way, turning the horses to the right when making the turns at *c* and *d*, the dead furrows will be located at *a*, *b*, and *e*, *f*. By continuing this system a series of years, the ditches are made deeper year by year. No ridge is formed on the sides of the ditch. By commencing the

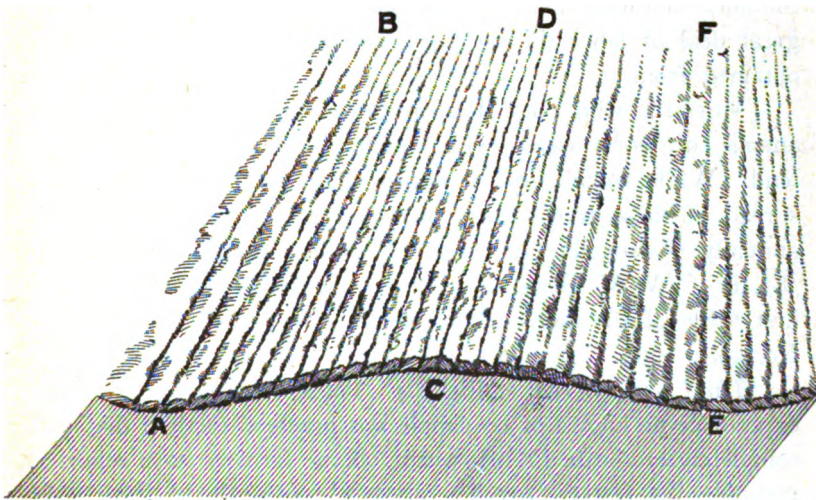


Fig. 7.—Plowing in Ridges.

plowing in this way, and by varying the back furrows one year a little to the right of *c*, *d*, and another year a little to the left, the dead furrows will be made broad rather than deep, making the fields gently undulate instead of being cut up by deep ditches and narrow high ridges. This method has been practiced since the farm was established, and the results are very satisfactory. The lands are wide enough so that there is sufficient water collected in the ditches to make a current. The same method of ridging the land has been adopted for the forestry plantation and for the fruit and vegetable gardens. Making the lands more narrow brings the broad ditches closer together.

WEEDS.

The presence of weeds on many farms in the Red River Valley demands that more rigorous measures be taken for their destruction. It is plain that so long as so few pastures, meadows, and cultivated crops are used in rotation with grain the farmers will find it very difficult to keep the weeds in check. Summer fallowing may destroy many weeds, but it requires a great deal of labor during the entire season, when no crop is obtained from it.

Mustard, wild oats, Pigeon grass, and French weed are among the worst weeds with which the farmers have to contend. While some effort is expended in their eradication, the spread of these weeds each year is greater than the numbers annually destroyed. In Minn. Bulletin No. 46, pp. 373 to 383, Prof. W. M. Hays discusses the methods of eradicating the first three of the above-named weeds. See, also, N. D. Bul. No. 39, p. 456.

The French Weed. (Fig. 8.) The writer regrets that from experience he knows of no simple nor practical method that will completely eradicate French weed. Some farmers have reported methods that have proven successful with them, but other farmers have tried the same methods and failed. In order to learn what could be done, a small tract of land was rented from Mr. Nils Roen, three miles south of Warren, for experimental purposes. This farm was so completely overrun with French weed that it seemed a very hopeless task to commence farming it. Fourteen methods were commenced with in the spring of 1899. The experiment will continue for three years, and inasmuch as only one year has passed, no report on results can as yet be made. Some things, however, have been learned. If this weed is to be destroyed, the work must be done thoroughly. The weed produces seeds so profusely that if one plant is allowed to go to seed a large area of surrounding land will soon be infested. If there is one direction in farming in which thoroughness is required, it is in trying to destroy this

weed. A slipshod way will not do, and an ounce of prevention is worth a thousand pounds of cure. Farmers whose farms are free from this weed should guard against their incoming with the utmost care and vigilance.



Fig. 8.—French Weed.—After Britton and Brown's Illustrated Flora.

The following are some of the methods employed in the experiments: (1) Grass crops; (2) cultivated crops; (3) early-maturing crops; (4) summer fallow.

It will readily be seen that to make the above crops profitable on the farms they must be fed to live stock. The farmers who intend to keep their lands free from weeds should lose no time in stocking them with cattle or sheep, or both.

Grass Crops. While grass crops will not completely destroy the French weed, they serve a useful purpose in keeping it down until the farmer can take hold of the field and work at it systematically. Many farms are very large, and it may at times be wise to sow part of the farm to *Bromus iner-*

mis or Timothy, and keep it in pasture or meadow until other fields are cleaned. Grass crops have a prominent place in those crop rotations which are most effective in weed destruction.

Summer Fallow. While the summer fallow is not to be generally recommended, many fields will continue to be fallowed, and it is best that the work be done according to some definite plan. The usual manner of summer fallow does not cause the destruction of as many weeds as it should.

The purpose of fallow cultivation is to bring as many weed seeds as possible to the surface and cause them to germinate, that they may be destroyed. To make the weeds start as early as possible in the spring, disk or harrow the fields. When the weeds are well started, but before any of them have gone to seed, plow the land shallow. This will destroy those weeds which were growing, and also bring a fresh lot of seed to the surface. Harrowing every eight or ten days will help to germinate more and destroy those freshly started. Later on, when the surface soil has no more seed left to grow, plow the land deep, and continue the harrowing. If this field can be put to some cultivated crop, like corn or potatoes, the succeeding year, the remaining seeds may be destroyed by the cultivator or hoe. Crops which may be planted late, and yet will ripen fairly early, may be used to clean the land of weeds. The late sowing will allow of cultivating early in the season to induce weed seeds to germinate. The weeds may then be destroyed while preparing the soil for the crop. The effectiveness of this method will be proportionate to the thoroughness with which the work is done.

Cleaning With Early-Maturing Crops. By sowing an early maturing crop, like barley or millet, the weeds will be stunted from lack of space to grow. The crop will mature for hay or seed, and may be cut and removed before the weeds go to seed. The land may then be plowed as soon as possible, and harrowed from time to time during the autumn. This method may not be as effectual as summer fallow, but it has the advantage of producing a crop. One part of the land should be thoroughly

cleaned, and kept clean, rather than an effort being made to clean the whole farm and thereby accomplish nothing.

In Europe, and later in America, experiments have been undertaken to kill various weeds with chemicals which destroy the weeds but do not injure the crops among which they grow. Some of these experiments have proven very promising, and some chemical may be discovered with which French weed may be effectually eradicated.

Upon the establishment of the Northeast Sub-experiment Farm at Grand Rapids, Minn., in 1896, Warren W. Pendergast, Assistant in Agriculture, a graduate of the School and College of Agriculture of the University of Minnesota, was entrusted with the responsibility of the superintendency. From the first he gave vigorous attention to planning new fields, buildings, roads, fences, investigation of soils, drainage of swamps, protection of young timber, reforesting the burned area, and the development of grasses, grain and forage foods.

Early in the summer of 1897 he was taken seriously ill, and died August 26, 1897. During the brief time he was engaged in this important work, he acquired much valuable information by his experience and observation, and had plans for the future development of the farm which merited approval. His marked, clear perception, strength of purpose in accomplishing work, his good sense in dealing with men, and his splendid character peculiarly fitted him for this position.

The work during the summer and fall of 1897 was placed in charge of R. W. Clark, who was assisting Mr. Pendergast at the time of his death. On February 1, 1898, Herman H. Chapman, a graduate of the School and College of Agriculture of the University of Minnesota, was appointed superintendent of the farm, and the work has been continued under his superintendency along the lines indicated by this bulletin, prepared by him. It being the first publication of any importance issued from the Northeast Sub-experiment Farm, it has been made rather general in its scope, and is intended as a popular treatise on the agriculture of the pine region.

The work done and the results obtained have been set forth in a way intended to emphasize certain fundamental principles of

successful farming in that region. An earnest effort has been made to reach and benefit the actual settlers. Many of these have had but little experience in farming. For this reason all facts of possible benefit to such individuals have been carefully stated. In treating so many subjects, the space allotted to each is necessarily limited.

WILLIAM M. LIGGETT,
Director.

St. Anthony Park., Minn., December, 1899.

NORTHEAST SUB-EXPERIMENT FARM.

HERMAN H. CHAPMAN.

LOCATION AND DESCRIPTION.

The Northeast Sub-experiment Farm of the University of Minnesota was provided for by the legislature of 1895. The site was chosen April 16, 1896, and the state acquired title to the property in July, 1896, in which year the work commenced. The location selected was in the vicinity of Grand Rapids, ninety miles northwest of Duluth, on what was then the Duluth & Winnipeg Railroad. This road has since become a part of the Great Northern System, connecting Duluth and Crookston.

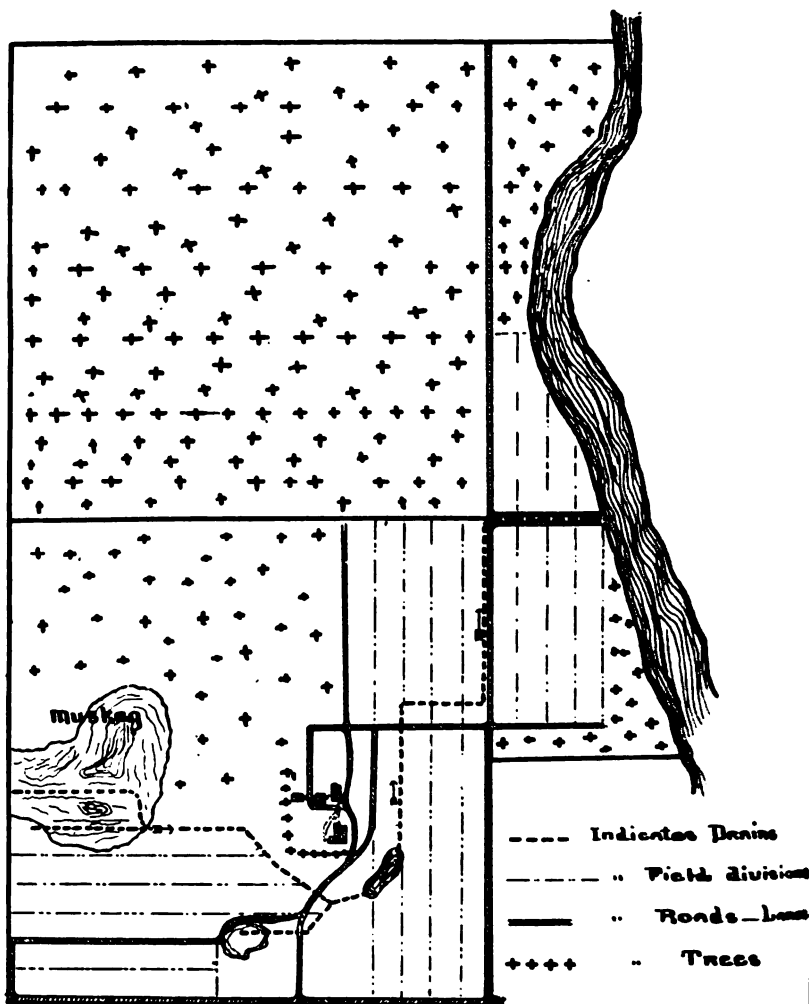
The farm lies two miles east of town; it includes the East one-half (E. $\frac{1}{2}$) of Section Fifteen (15), Range Twenty-five (25) W., Township Fifty-five (55) N., and Lots Six (6), Seven (7) and Eight (8) of Section Fourteen (14), lying along the west bank of the Prairie River; in all, about three hundred and seventy-five acres. The object in establishing this farm was to study the agricultural possibilities and investigate the problems of that great district in northern Minnesota known as the "Pine Region." This was to be accomplished by means of carefully conducted experiments, dealing with questions which, on account of peculiar local conditions, could best be determined by experiments conducted in this region. The nature of the work requires the annual outlay of a considerable amount of money, which must be regarded as an investment by the state in obtaining results and facts which the farmer, unaided, cannot secure.

This region was originally covered with pine, hardwood and swamps. It extends from the northern boundary of the state south for two hundred miles, and from Lake Superior one hun-

dred and fifty miles westward to the Red River Valley, and comprises over one-third of the total area of the state. In this vast territory there is quite a range of climatic conditions and a great variety of soils and timber, which made it necessary to choose a location for the station where the results of the work would be most widely applicable. Most of the settlement has heretofore been to the south of Grand Rapids. Yet this point is more nearly in the center of the pine region than any other site considered at that time. Its northern location is an advantage in testing crops of all kinds for hardiness.

The farm itself contains as great a variety of soil conditions as can be hoped for on a single section, all distinct types being represented except the dense red clay of the Duluth district. The portion which was first cleared is a light sandy loam soil, such as is found over large areas and usually grows Jack or Norway pine. Such soils may be underlaid with clay, but at variable depths. They represent the poorest class of soils, very fertile for a few years, but requiring careful management to retain their strength. Near the Prairie River the underlying clay rises close to and finally reaches the surface, forming a light-colored clay soil of great value. These clay soils are unevenly distributed over northern Minnesota and are found sometimes in large tracts, generally near watercourses and lakes. On the west side of the farm, bordering a large swamp, the soil is a fine silt, and low lying. With good drainage this is proving to be a very fertile field. The swamp mentioned is of the type called "Muskeg," an adopted Indian word. It is too wet to grow tamarack, and is filled to a level surface with an accumulated vegetable growth forming a thick layer of peat, or muck, upon which grows a mat of sphagnum moss and low shrubs. This peat may be from one to thirty feet deep and rests usually upon a bed of clay or a marl deposit. In some districts, swamps of this character are found that cover many square miles, and they are widely distributed. This muskeg and a smaller one are so situated that they can be drained; and the methods, cost, and practical results of bringing them under cultivation determined. The opportunity thus given to deal with a problem of such wide

application was clearly recognized in selecting this site. On the north quarter section lies a tamarack swamp and natural meadow,



Plan of Northeast Experiment Farm.

Fig. 1.—General Plan of the Northeast Sub-Experiment Farm, Grand Rapids, Minn.

such as is found along river banks and streams where the soil has had sufficient drainage to prevent the formation of the

muskegs. All the marketable pine had been removed from the land before its acquisition, but there remained a large quantity of timber of other kinds. All land near the river not swampy bore a heavy growth of poplar and birch, with some oak, elm and balsam fir. On the higher land Jack pine is prevalent and there are several promising groves of young White and Norway pine.

EQUIPMENT.

Buildings.—The buildings on the farm consisted of a five-room dwelling, a horse barn for four teams, a chickenhouse, roothouse and icehouse. The house has been completely transformed into a modern farmhouse of ten rooms, and now provides ample accommodation for the station force. Two lean-to sheds have been added to the barn, serving as shelter for machinery and wagons, with lofts for storing seeds and tools. The roothouse, originally built of Norway timber, was found to be completely rotted out. The old timbers were removed and a new roothouse built of stone with cedar timbers for the roof covered with five feet of earth. The doors admit the entrance of a wagon, which saves much time in handling potatoes or roots. A pigpen has been constructed, and the chickenhouse, which was much too large, has been transformed into a sheepshed, for which it is well adapted. A watertank holding thirty barrels has been mounted in the tower of the windmill and pipes laid to the house, barn and sheepshed. Below this tank and over the pump was built a stone milkhouse. The tank was incorporated into the roof of this house as a tower. To protect the tank against freezing it was boarded in, leaving an air space which was filled with cut straw. The outside was papered and shingled. This has proven entirely satisfactory. The walls of the milkhouse were built of stone, taken from the field, laid with their rounded surfaces exposed, giving a very pretty effect. The floor, with a drain in the center, is cemented. This house, which is thus in direct connection with the water supply, is used in separating the cream and in churning. Some machinery was purchased with the farm, and subsequent

additions have well equipped it. The acreage which has been fully cleared of stumps makes it practicable to use all modern farm machinery in place of the primitive methods necessary on partially cleared fields. At present, the station possesses the only self-binder and threshing machine in the county, but mowers are coming into general use, and other modern machinery will soon follow.

Live Stock.—The farm has always kept a pure-bred bull of one of the milk breeds, and is building up a herd for dairy



Fig. 2.—New Farm House, Northeast Sub-Experiment Farm.

purposes by upgrading common stock and raising the cross-bred heifers. Pure-bred swine are kept and the young stock registered and sold at reasonable prices to settlers. A carload of one hundred ewes of western grade Merino sheep were imported in the fall of 1898, half of which were sold to settlers in the neighborhood, and half retained on the farm. This type of sheep was selected as being hardy and vigorous, well able to stand cold and

exposure, and better fitted than any other to use in clearing up brush land. They will make a vigorous foundation stock for improvement by crossing upon them one of the improved mutton breeds. As soon as possible, a barn will be built for the dairy herd, which is now quartered in the horse barn. The number can then be considerably increased. It is the object of the station to have enough live stock to consume all the roughage raised on the farm, thus giving a large supply of manure and maintaining the fertility of the soil.

CLEARING THE FARM.

The land already cleared when the farm was acquired comprised about seventy acres, most of which had been very easily brought under cultivation. A large part of it was light soil, and it had been necessary to remove only a growth of brush, scattering trees and stumps. The cleared area has since been increased to one hundred and twenty acres. The new clearing has been done in a way to straighten the outlines of the fields, bring the clear portion of the farm into a compact body, and bring under cultivation those fields which contained the best soil and gave the most uniform conditions for experiment work. Most of the land is too rolling to be useful for field experiments, but some of the newly cleared land is level and uniform, giving conditions where it is possible to conduct experiments requiring close comparison on similar plots of ground. Two fields, aggregating about twenty-five acres, were cleared next to the river, out of the heaviest growth of timber on the farm. The cordwood was cut at seventy-five cents per cord, and yielded from twenty-five to thirty cords per acre. The tops were then piled and burned, and the stumps pulled with a windlass stump puller, cleared of dirt and burned, leaving the field ready for the plow. This work was done by contract for thirty dollars per acre, and the value of the labor actually put upon it came fully to this figure. It was necessary to clear this land completely at one operation, as the piece was needed for experiment work. The cost was, consequently,

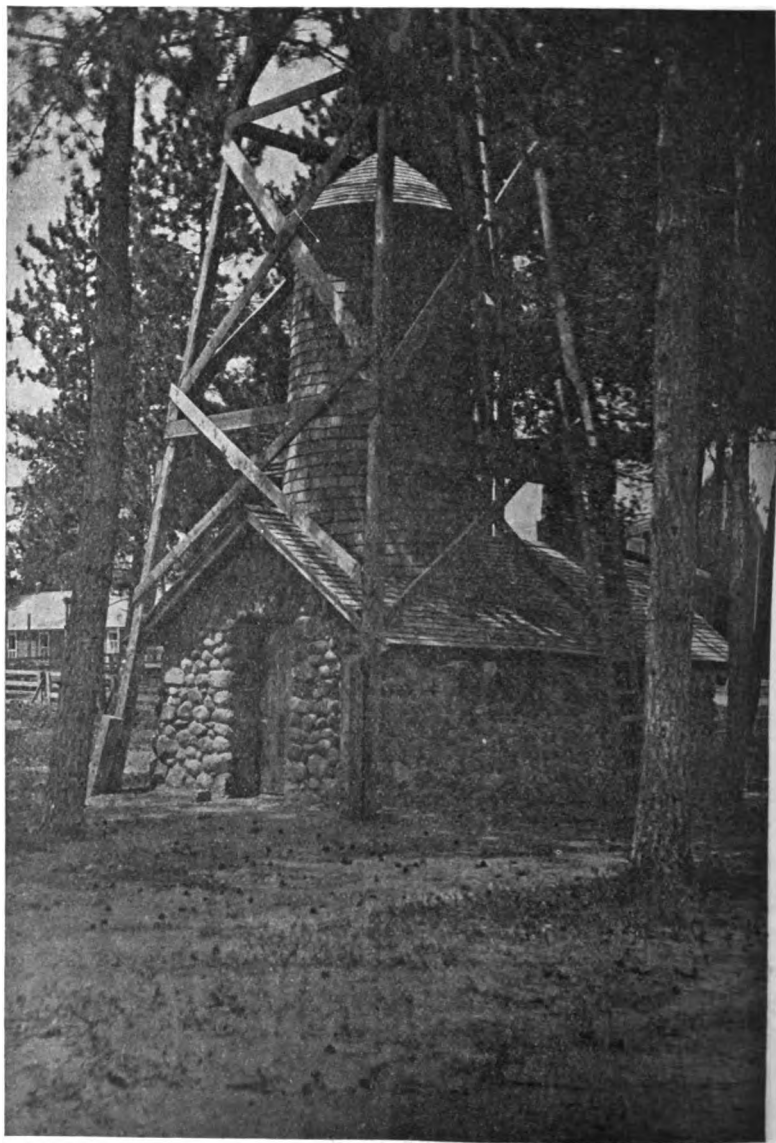


Fig. 3.—Milk House and Water Tank.

higher than if slower methods had been used. It is seldom best to pull stumps at once, provided they can be prevented from sprouting. Stumps of deciduous trees, commonly called hardwood to distinguish them from evergreens, rot in four to seven years. Pine stumps are slow to rot, as the resin they contain preserves them from decay, but if allowed to stand a few years the smaller roots rot off and they bring up much less dirt with them when pulled. The stumps pulled on this field by means of a windlass stump puller brought up large masses of earth, leaving great holes in the field. This dirt had to be detached with picks before the stumps would burn properly. The labor of pulling, and the cost of handling and piling, was much greater than it would have been with rotten stumps. To keep down the sprouts and get some return from the land while this rotting process is going on, it is wise to seed down and pasture the field, or, when the stumps are not too thick, to plow between them for grain crops. These are the only methods practicable for a man of small means, as it both reduces the expense and distributes the labor over a number of years. When the ground is thickly covered with large pine stumps the expense of removing them is very great. If pulled entire, they require a powerful machine, and are very bulky and troublesome to handle afterwards. If dynamite is used it requires a heavy charge to dislodge them. The method which has seemed to give best results is to use a charge sufficiently heavy to split the stump into two or more pieces and then to pull the pieces separately with a stump puller. Dynamite has been used on the farm in removing stumps to study its comparative cost and efficiency. A charge of one-half to one and one-half pounds will remove poplar or other "hardwood" stumps, one to one and one-half feet in diameter, split them so that it is an easy matter to remove the pieces. The charge is inserted beneath the stump in a hole made with a crowbar or auger. Stumps so removed are quite clear of dirt and may be piled up and burned to better advantage than stumps which are removed wholly by means of the stump puller. Taking these points into consideration, the

cost of removing such stumps with dynamite will probably average about the same as in pulling them, but it is more expeditious and does away with over half of the heavy hand labor.

Fire is the greatest aid the settler has in clearing land, but it can easily be abused. Many districts have been first opened to extensive settlement by the work of fierce forest fires which burned nearly every vestige of rubbish from the ground. Settlers are thus apt to regard fires as only a benefit, especially where there is but little valuable timber and a poor market for cordwood.



Fig. 4.—Experimental Gardens and Field.

They do not realize the nature or extent of the injuries resulting. Fires thus set are seldom kept under control. In a dry time they may do immense damage to standing timber and to buildings, fences, and personal property. They are almost sure to injure young timber, which, if not so destroyed, might be valuable later. Lastly, they have a very injurious effect on the land itself. In its natural state the soil in this region, almost all originally wooded, is both filled and covered with an abundant supply of decaying vegetable matter, such as dead leaves and roots. This

rotten material is known as "humus." It has the power of absorbing and holding a great deal of water, so that a soil plentifully supplied with it may have twice the power to resist drought that it would possess without the humus. Humus is a plant food itself, and by its presence and decay sets free more plant food in the soil. A sandy soil without humus will soon wear out, but with an abundant supply of humus kept up by proper crop rotations, its fertility may be maintained. Severe burning in a dry time will burn up and waste the humus, even that which is in the upper portion of the soil. If such means are adopted to clear the land the loss of fertility will in many cases more than offset the saving in the cost of clearing. The use of fire should be limited to seasons and conditions when the ground is damp enough for its own protection. It may sometimes be advisable to set a running fire over land to be cleared when the soil is not too dry and where there is good opportunity to control it, and the rubbish is very thick on the ground, but, in general, fire should only be used for burning brushheaps and piles of logs and stumps. This latter was the method used on the fields cleared next to the river on Northeast Farm. The soil here was covered with a deep layer of humus, and had evidently never been burned over. This was not injured in clearing and was turned under and mixed with the soil, thus insuring the fertility of this field for many years.

Having obtained ground suited to its immediate needs, N. E. station can now practice more economical methods of clearing. The flock of fifty ewes, purchased in 1898, are being used in this work. A pasture of thirty acres was fenced off for them in the woods. It is intended with their assistance to clear this up gradually. The trees are being cut into cordwood and the tops burned. All brush which is too high for the sheep to reach is cut down with the brush scythe. The sheep in one season have prevented the growth of all new sprouts wherever this has been done, and give promise in another season of completely killing the underbrush in this pasture. Their manure is, at the same time, greatly benefiting the soil. This pasture is so arranged that the sheep may be turned into a field where some pasture crops are provided,

in case the feed in the woods becomes exhausted. This is likely to occur in the fall. Sheep of the grade used seem to do well on the rough feed in the woods with no other pasture, but probably this will not be true of the improved breeds. By so arranging the sheep pasture that the sheep are confined to the woods in the morning, and are allowed access to better pasture in the afternoon, the best of the mutton breeds may be grown with profit, without losing their usefulness in the work of clearing lands. It is found best to have the sheepshed accessible at all



Fig. 5.—Flock of Western Sheep Used in Clearing Brush Land.

times in the summer, allowing the sheep to choose their own time for feeding and to escape from the attacks of flies and from the heat.

Cattle will aid in clearing by browsing, but their work is very incomplete and in no way comparable to that of sheep. Where wolves are abundant it may not be profitable to raise sheep, but this is not true of many sections.

This problem of clearing the land is the foremost one which confronts the settler and will occupy a large portion of his time

and thought. The cost of complete clearing will vary, as was seen, with the methods employed, length of time consumed, and with the character of the timber and soil. For better soils it will range between six and thirty dollars per acre, although some poorer or sparsely timbered land may be cleared at a lower figure. This expense should be borne in mind in placing a market value on uncleared land intended for agricultural purposes. Speculators should not make the mistake of supposing that such lands, if bought at a low figure, will find a ready sale at double or treble the price in the near future. The class of settlers that have the means to pay good prices for land will prefer to buy where they can obtain land already cleared, if they can get it for less than it would cost them to buy and clear these lands. The selling price of this uncleared land should remain low. This region must and will be developed by the man of small means, but large endeavor, who values a home and independence above ease and comfort; whose capital is his strength, and who will create by his labor and perseverance, in improvements, the value of the farm he could not have purchased outright. Homestead land and low-priced land enable such men to acquire title to a farm which they can clear up gradually, supporting themselves, in part by selling cordwood or working in the woods in winter, until the farm is cleared sufficiently to maintain them and their families.

SWAMP LAND.

DRAINAGE.

The first necessity in subduing swamp land is proper drainage. The two muskeg swamps on the farm were so situated that they could be well drained by constructing a rather deep ditch, lessening in depth as the ground fell away towards the river. This ditch was dug in 1896-97, and was nearly a mile in length. It lowered the water in the muskeg about a foot and permitted the cultivation of the adjoining fields. In 1898 the ditch was deepened, to drain the swamp to a greater depth. The action of the frost and water on the sides of the ditch thus deepened caved them in badly and made it impossible to maintain the desired depth without too great an excavation. In 1899 the ditch was dug out again to a permanent depth and made two feet six inches wide at the bottom. Straight tamarack poles sixteen feet long were laid along the sides as cribbing. These were held in place by posts about three inches thick driven into the bottom of the ditch opposite each other about four feet from each end of the timbers, which were notched to receive them. The posts of each pair were held apart by a cross-piece notched at the ends and inserted between them. This cribbing runs throughout the deeper portion of the ditch and into the muskeg, until the muck is reached, where it becomes unnecessary. The first outlay is rather large, but the work is lasting and in this case absolutely necessary. For lack of the additional depth, now secured, no work could be done in the swamp during the wet season of 1899. It is thought that this form of ditch is more practical than a large tile drain for such conditions where the ditch must be dug through soil which will wash or fall down along its sides, as it can be constructed from material at hand and is less expensive than tile in this northern country. It is not always necessary to protect the sides of a ditch from caving. Ditches in the swamp itself need no support, as the peat retains its form and upholds the sides of the ditch. Where shallow enough the sides can be given sufficient slant to

prevent such caving. Many swamps and small bogholes are easily drained by a shallow ditch.

The first ditch was dug across the south end of the swamp, cutting off about one-half acre to the south. A ditch was then dug running north at right angles to the first, and then west, parallel with the first ditch, thus enclosing about two acres of the muskeg. Short lateral covered drains will probably need to be constructed to drain the interior of this piece, but by running the ditch around it in this manner the flood water from



Fig. 6.—Draining a Muskeg With an Open Ditch.

the adjoining highland is completely excluded from flowing through and over the undrained portion of the swamp. In 1899 the portion so drained was comparatively dry in spite of the imperfect condition of the outlet ditch, while water was running into the ditch at all points on the opposite side. Covered drains can be made by opening the ditch as for laying tiles, filling in the bottom with poles two or three inches in diameter, then a layer of shrubs or limbs of trees, and filling the ditch with the peat taken out in opening it.

CULTIVATION OF PEATY SOILS.

The typical muskeg, such as this, is always covered with a thick layer of the peculiar moss known as "sphagnum," which, on account of its power of holding water, is used by nurserymen as packing material for nursery stock. Through this grows a low shrub with long roots, binding the moss into a stiff mat of vegetation. This must be gotten rid of by some means before any use can be made of the soil. Burning is not very successful; the moss will remain damp until the water is nearly all dried out of the

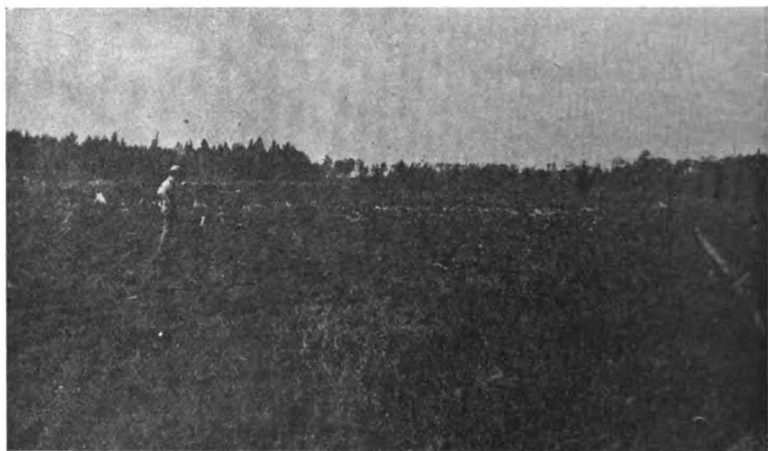


Fig. 7.—Muskeg After Clearing, Draining and Breaking.

lower layers. Burning before the moss is thoroughly dry will accomplish but little, as the fire skims over the surface and leaves the bulk of it intact. When the swamp is dry enough for the moss to burn thoroughly, which seldom occurs unless it is drained, there is greater danger of the fire getting into the lower layers of the peat and burning for a long time, leaving large irregular holes in the surface, and thus doing great damage. It is not practicable to turn this moss under with a plow. It is too difficult to cut with the coulter, and rolls up in large masses and is slow to decay, so that an attempt to plow it will leave the land in worse condition

than before. When this fact had been sufficiently demonstrated by trial a new method was adopted. The moss was stripped from the portion of the swamp south of the ditch by pulling it loose with potato hooks and carting it to one side, leaving the compact lower peat exposed. A clean furrow was easily turned in this soil, and the whole piece was broken with a plow. The expense of removing the moss by this process makes it impracticable to apply it on a large scale; but it is thoroughly efficient. Cheaper methods will be tried for getting rid of the moss. It will probably be possible to pull the moss loose from the peat, or even overturn it, and thus dry and burn it successfully where it lies.

The small piece first cleared is ready for the experimental work to test its capacity for crop production, which will begin in 1900. This muskeg represents the type of swamp land most difficult to subdue and of most doubtful value to agriculture. Swamps bearing a growth of large tamarack or spruce are, when properly drained, sometimes cleared at a much smaller cost per acre than their appearance would indicate. This is due to the manner of growth of the roots, which spread over the surface and have no tap roots to remove in pulling. Such swamp land will usually make a fertile and lasting soil.

FIELD MANAGEMENT.

The general lines of farm policy pursued are such as are best calculated to maintain the fertility of the farm and at the same time give profitable crops. The soil over a portion of the farm is sandy, resembling that found over a large portion of northeastern Minnesota. Such soil will produce large crops for a few years, but if carelessly farmed and kept continuously in potatoes or grain without manure, it cannot be expected to retain its fertility. The principle means for accomplishing this end are manuring and a proper rotation of crops, in which grass and cultivated crops alternate with grain. To produce all the manure possible and to feed on the farm most of the produce raised on it, so as not to remove the fertility from the farm in the crops sold, it is necessary to keep all the stock the farm will support. Every farmer in Northeastern Minnesota should keep as much stock as the nature of his farm and methods of farming will allow. The live stock on Northeast Farm have been steadily increased, but has not yet reached the point where all of the field products are consumed on the farm. The manure obtained from the stables in the summer is composted and spread in the fall, but during the winter it is hauled direct to the fields and spread. Stable manure is the cheapest and best manure to use on this class of soils. It is produced on the farm, and the straw and litter with which it is mixed change to humus in the soil. The manure rots gradually and lasts more than one season. Commercial fertilizers, on the other hand, represent an outlay of money, and their effect will seldom be noticeable after the first one or two seasons, as they soon wash out of a loose grained soil.

The application of manure is second in importance to, and only a part of the general plan of cropping to be pursued on the farm. Even if the cleared area is small and it is necessary to keep a large acreage in permanent pasture where the stumps have not been removed, the crop on the clear fields should be rotated, and potatoes or grain should not be grown continuously

on the same ground. The kind of rotation pursued will depend upon the amount of live stock upon the farm. It will be hard to plan a rotation that will maintain the soil in good condition, unless crops such as clover and fodder corn, are raised to be fed on the farm and the manure returned to the soil. Upon the North-east Farm the principal field crops are fodder corn, oats and tame hay, mixed clover and timothy. These crops are all fed, as far as needed, on the farm. The manure thus obtained is applied to ground intended for corn and plowed in the spring. The corn ground, which is kept clean of weeds, is put into oats, using the disk harrow to prepare the soil instead of plowing it. Clover and timothy seed are sown with the oats. The hay crop will be largely clover the first year and the year following will consist mostly of timothy. The sod is allowed to lie only two years when it is plowed up and again put into oats or corn. The rotation may consist of fodder corn, oats, meadow two years, then oats, spreading the manure on the oat stubble and again planting fodder corn, making a five-year rotation. By putting the sod ground into oats and again seeding down, a three-year rotation will be established. This latter rotation has been practiced on fields which it was not possible to supply with manure. By shortening the meadow to one year the second growth of clover of that year may be plowed under as a green manure. This has been done on a part of the meadow the past season. This is an economical way of supplying a large quantity of humus to the soil and the benefits derived from the decaying clover in the soil will, in the increased yield of grain, offset the disadvantage of losing the meadow. The general effect of these rotations is to maintain or increase the fertility of even very poor soil. The manure and the sod contribute to this result, but the part that the clover plays is important and must be clearly understood. Clover and plants related to it, as peas, have the power of collecting nitrogen from the air and leaving it in the soil. No other class of plants can do this, but depend upon the nitrogen already in the soil for a part of their food. Nitrogen is the most easily wasted and soonest exhausted of all plant foods in the soil, and this power of the

clover to increase instead of diminish the supply of nitrogen accounts for its wonderful fertilizing action upon soils.

These rotations are not the only ones that can be practiced. Potatoes and roots, winter rye and crops for pasture, will necessitate a different order of cropping, but the general plan outlined above can be followed with profit under many conditions.

While the results obtained in the work so far have shown the advantages of such rotations, experiments have also been started to demonstrate by actual tests the comparative effects of numerous different rotations and their suitability for the many soil conditions. Plots have been laid off on ground as uniform as can be obtained, and this year's crop of hay has been cut from each plot separately to compare the yields of the plots. The results have shown a satisfactory uniformity of yield from the different plots, showing that the several plots are nearly equal in fertility and other characteristics. On each of these plots a different plan of crop rotation will be inaugurated, and the result of a trial for a series of years will show the effect of the rotation on the soil and the relative profits of the crops produced.

VARIETY TESTS.

As the conditions of soil and climate existing in the pine region are peculiar to this section, it appears reasonable that some varieties of grain and other crops will prove better adapted to these conditions than will others. To seek to determine by careful comparison and trial what varieties are best, and then if possible to propagate them for distribution, has been one of the chief aims in the work of N. E. station. This is work which, while it is constantly being done in a small way by the farmer, can only be carried on thoroughly and efficiently on a large scale, such as no farmer has the time or means to adopt. The results of the tests made during the last four years at the station have shown that great variation exists, and these tests have clearly proven the superiority of some varieties over others.

In testing small grains the object sought is to obtain those varieties which give the largest yield. To secure a proper com-

parison the different varieties are grown side by side on plots of equal size and given uniform conditions of planting and treatment. Each plot is harvested when ripe, shocked and threshed separately, and the straw and grain weighed and recorded. The ground selected for such tests must be uniform. The comparative yields of grain grown on poor soil will be as valuable in testing varieties as those obtained on richer fields. Thus in 1898 the varieties of grain were grown on the poorest field of the farm, and the field grain grown on the other fields exceeded them in yield, but the variation was just as marked as it would have been on the better soil.

VARIETIES OF WHEAT.

The yields of wheat were seriously injured by water in 1896 and 1899. The necessity of selecting level ground for the tests made this misfortune possible in the wet season as the level land was low lying. A perfect system of surface drainage is thus made necessary that valuable tests may not be interrupted in this manner.

During the four years' work twenty-one varieties of wheat have been grown. These varieties came originally from Minnesota, the Dakotas and Canada, as it has already been shown by tests conducted at the University Farm, that the best wheats for Minnesota are those now grown in the state. They included varieties of Fife and Blue Stem wheats, and one or two bearded wheats. Only four wheats have been grown consecutively for the four years. Some have been rejected on first trial and others after having been grown two or three years. An average yield is more to be depended upon than the yields of a single year, as the difference in seasons seems to affect varieties differently. The best varieties for a given locality are those that will average the best for all seasons.

TABLE I.—Wheat Yields of Four Varieties for Four Years.

Minn. No.	Variety	1896	1897	1898	1899	Average for 4 years	Average for '97-'98
146	Bolton's Blue Stem.....	8.2	19.4	19.3	13.0	15.0	19.4
51	Hayne's Blue Stem.....	11.4	12.4	23.0	11.7	14.8	17.7
66	Power's Fife.....	8.6	11.9	20.7	8.7	12.5	16.3
105	Glyndon 711	8.4	12.2	14.7	10.5	11.4	13.5

TABLE II.—Wheat Yields of Fifteen Varieties for Two Years.

Minn. No.	Variety	1898	1899	Average for 2 Years
51	Hayne's Blue Stem.....	23.0	11.7	17.4
169	Hayne's Blue Stem.....	19.3	13.4	16.4
146	Bolton's Blue Stem.....	19.3	13.0	16.2
165	Wellman's Fife.....	20.7	11.4	16.1
171	Risting's Fife.....	16.7	12.9	14.8
181	McKendry's Fife.....	17.3	12.2	14.8
66	Power's Fife.....	20.7	8.7	14.7
157	Glyndon 753.....	16.2	12.3	14.3
188	Preston.....	15.2	13.4	14.3
167	Glyndon 761.....	15.7	11.7	13.7
149	Power's Fife.....	14.2	12.3	12.1
185	Advance.....	16.5	9.4	13.0
155	Glyndon 818.....	14.7	11.0	12.8
163	Glyndon 811.....	14.7	10.7	12.7
105	Glyndon 711.....	14.7	10.5	12.6

These results seem to show that in Northeastern Minnesota Blue Stem wheats will average two or three bushels per acre more than the Fife varieties, when grown under similar conditions. The notes which were taken on rust show that the Blue Stem wheats were less affected by rust than Fife wheats, which may account for this difference. Of the Fife wheats Wellman's has given

the greatest promise; it has been grown but two years. In 1898 this wheat was grown for the field crop and yielded 100.3 bushels on a field of three and one-half acres, or 28.6 bushels per acre. This field has been cropped for four years, three in potatoes and one in barley, and was manured for the barley. A small trial plot of wheat was grown in 1898 on new soil which proved too rich for it, causing it to lodge badly. The grade of the wheats raised here has varied with the season, but has averaged lower than the same varieties raised on the Northwest Experiment Farm in the Red River valley. This is, no doubt, partially due to our moister climate and the different character of the soil. Wheat should not be grown on a newly cleared field, until two or three other crops have been taken from it and the soil worked upon and mellowed. It is best to have it follow corn in rotation, especially if the corn has been manured. When properly grown, the yields will equal or exceed those obtained on the prairie where drought frequently occurs. But the growing of wheat in this section should be limited. When the cleared area is small, and especially when the stumps prevent the use of modern harvesting machinery, it will not pay to raise wheat in competition with the prairie sections. The sale of wheat from the farm will also remove much desirable fertility. Where grist mills are established it will pay to raise wheat as needed for home consumption or to supply a local demand, but stock farming will generally prove more profitable than all grain farming in this section.

VARIETIES OF OATS.

As long as lumbering continues in the pine region there will be a good market for oats. The oat crop is now the most important grain crop raised here. Oats will do better on new and raw soil and under adverse conditions than any other grain crop, and under favorable conditions will yield large crops.

Twenty-three varieties of oats have been tested on the Farm grounds. Nine of these have been grown continuously for four years. Most of the others have been discarded as inferior.

TABLE III.—Oat Yields of Nine Varieties Grown for Four Years.

Min. No.	Variety	1896	* 1897	1898	1899	Average for 4 years
6	Improved Ligowa	38.6	65.6	61.3	43.7	51.9
23	Lincoln.....	30.0	67.6	46.3	41.9	46.5
35	White Russian.....	35.7	61.7	41.9	40.9	45.1
4	Early Swedish.....	37.1	53.6	49.4	36.3	44.1
64	Black Russian	28.6	60.4	43.8	37.4	42.6
2	White Wonder.....	29.3	56.1	49.4	35.3	42.5
29	Archangel.....	30.7	50.6	52.5	36.3	42.5
26	Early Gothland.....	21.0	63.4	45.0	40.7	42.5
36	Giant Side.....	25.7	58.7	46.9	29.4	40.2

The Improved Ligowa has so far shown itself to be a heavier yielder than any other variety grown; averaging over five bushels per acre more than the Lincoln oats, which come next in order. In 1899 all the grain on hand of this variety, the yield of a one-tenth acre plot of the year previous, was sown and a field of grain in 1900 will be grown entirely of this variety, which will enable the station to distribute it for seed in 1901.

The variety called "Minnesota No. 35," sometimes wrongly called "White Russian," has so far been the field crop. In 1898 a field of 11.5 acres yielded 701.3 bushels, or 61 bushels per acre. In the spring of 1899 four hundred and fifty bushels of this variety were sold for seed oats and more will be available in 1900. The yield in 1899 on a four acre piece was 218.5 bushels, or 54.6 bushels per acre; nearly all the varieties given in the table are valuable. They appear to maintain their yield and weight well. Minnesota No. 36 (Giant Side) is a late side oat and a lighter yielder. The others are all medium early, open-panicked oats. Two new varieties, Houston's Silver White and Golden Sheaf, tested in 1899, gave a slightly better yield than any of these and will be tested farther. Some oats when brought into this section from other regions tend to lose weight and yield. Those varieties that maintain their good qualities should be quite valuable for general growth.

VARIETIES OF BARLEY.

Only four out of seventeen varieties of barley have been grown continually for years.

TABLE IV.—Barley Yields of Four Varieties Grown for Four Years.

Minn. No.	Variety	1896	1897	1898	1899	Average for 4 years
6	Manshury.....	29.1	36.2	28.9	28.7	30.7
26	Manshury.....	19.4	31.6	28.7	32.5	28.1
28	Bernard's.....	26.0	30.1	26.3	26.2	27.2
7	Champion of Vermont.....	26.5	32.3	26.3	16.4	25.4

The results show that the six-rowed barleys are the best yielders; out of these the Manshury is much the best. Two different strains of this variety, Minnesota No. 6 and Minnesota No. 26, were tried, both of which proved better than the other kinds. Of the two-rowed type, Minnesota No. 7 (Champion of Vermont), is the best that has been tried. A field of 24 acres sown to Minnesota No. 6 barley, in 1898, gave 98.3 bushels, or 41 bushels per acre. Barley should be raised here only for feed. Its best use is for hogs. Like wheat, it is not profitable to grow for the market on small, half-cleared fields.

All the small grains are sown on fall plowing, or on corn land, which is worked up with a disk harrow in the spring. Spring plowing leaves the soil too loose for grain and retards the seeding. Grain should have a rather compact seed bed, and should be sown as early as possible in the spring. Wheat should be sown as soon as the ground can be dragged and before the frost is all out of it; if sown later than May 1st, it will seldom yield a full crop. In 1898 the wheat was sown April 18th and ripened in 115 days. Wet weather delayed the sowing of the land selected for wheat in 1899, until May 5th, and the yield was seriously lessened. The oat crop was sown in 1898 on April 25th and ripened by

August 8th, averaging 107 days. Barley is most apt to be injured by a late spring frost and cannot safely be sown much before May 1st in this latitude. In 1898 the crop was sown April 27th and escaped injury. Where grain is sown early it forms a better root system, is better able to resist drought later on, ripens somewhat earlier, is not so much injured by rust and will generally produce a better yield.

FIELD PEAS.

Field peas have been grown every year with only moderate success. The variety tests have shown that the small white pea, generally known as "White Canada" field pea, gives best yields of grain; yields of twenty-five to thirty-two bushels per acre were obtained in 1898 on twentieth-acre plots. The climate is well suited to peas, but they are found to do best on a heavy clay or clay loam soil. On light sandy, or sandy loam soils, they will not succeed as well as other grain crops or clover. A large acreage should not be planted to peas, until they are first tried in a small way to note whether the proper conditions for their successful growth are present. Where they can be grown they make one of the most valuable stock foods to be found and can be fed green by pasturing hogs or sheep upon them, or by cutting and throwing to hogs for them to thresh out. Peas act upon the soil in the same manner as clover by adding nitrogen to it.

VARIETIES OF CORN.

Corn has been ripened by the Indians much farther north than Grand Rapids for a long time past. The varieties obtained from this source, known as "Squaw Corn," are rather small with ears near the ground. By selection and improvement strains have been bred from this stock that are much superior to the old kinds. Flint corn has been pushing farther and farther north and supplanting the "Squaw Corn," and of late years a few hardy varieties of Dent have become acclimated as far north as Aitkin and

Duluth. Corn is more susceptible to slight variations in climate than any other crop, and a difference of one hundred miles north or south necessitates the use of different varieties of corn for the best results. A variety of Dent corn may not ripen at Grand Rapids, and yet may be adapted to conditions about Aitkin or Brainerd. Corn is easily improved by careful selection or by crossing two or more kinds followed by selection of the best resulting types. This process of selection is carried on, consciously or unconsciously, by all corn growers. To this power of variation and acclimatization, aided by selection of seed, is due the gradual improvement and northern extensions of the better varieties of corn.

The work of Northeast Farm has been that of testing all varieties thought to be best suited to northern conditions, for the purpose of selecting some that may be an improvement over those now being grown. The best of these will be grown in an effort to still further improve them. About fifty varieties have been tested. No attempt has been made to keep these separate; their number made this impossible, and it was more important that they be tested under the same conditions of soil and drainage. The plots were grown side by side. Sufficient seed is procured from the original source to allow some to be saved pure, to be used if the variety is worthy of propagation.

The smaller and hardier flint varieties will ripen with a fair degree of certainty. The Palouse corn, from Washington state, is smaller and earlier than any other variety tested, and will, undoubtedly, ripen much farther north than Grand Rapids, even beyond the Canadian line. The most promising Dent corn is a variety obtained from Mr. Jacob Berg, of Mentor, Polk county, Minn. This corn ripens several days earlier than any other Dent tried, and by careful selection and adaptation can probably be made a sure crop for this vicinity. Larger Dents, like the Golden Drop and St. Cloud yellow Dent, are a little too late for a sure crop as far north as this, though in good seasons and favored localities they might ripen; they should be reliable below Aitkin or Wadena. Steady improvements may be looked for along this line, and as the varieties improve, it will become more profitable to raise corn for ears.

TABLE V.—Corn Varieties Grown in 1899.

Variety	Name	Where Obtained	Height	Length of Ear	No. of Rows of Kernels	Condition When Frozen
Squaw.....	Crawford's.....	Grand Rapids	3 ft. 6 in.	7 in.	8	Ripe
Squaw.....	Poole's.....	Grand Rapids	3 ft. 6 in.	7 in.	8	Ripe
Squaw.....	Fuller's.....	Warren.....	3 ft. 6 in.	7 in.	8	Ripe
Flint, White.	Dakota.....	Minneapolis..	4 ft.	8 in.	8	Ripe
Flint, White.	Will's Dakota....	Bism'r'k, N.D.	4 ft.	8 in.	8	Ripe
Flint, Yellow	Lisquist's.....	Wadena.....	5 ft.	8 in.	8 to 10	Ripe
Flint, Yellow	Gehu.....	Bism'r'k, N.D.	4 ft.	8 in.	10 to 12	Ripe
Flint, Yellow	Tweeton's.....	Crookston.....	4 ft. 9 in.	8 in.	8	Ripe
Flint, Yellow	Minn. Wh. Flint	Minneapolis..	5 ft. 6 in.	8 in.	12 to 16	Glazing
Flint, Yellow	Triumph.....	Minneapolis..	5 ft. 9 in.	10 in.	12	Glazing
Flint, Yellow	Mercer.....	Minneapolis..	6 ft.	9 in.	12	Dough
Flint, Yellow	Longfellow.....	Minneapolis..	6 ft.	8 in.	8	Early dough
Flint, Red....	Lommen's.....	Crookston.....	5 ft. 9 in.	8 in.	10 to 12	Dough
Flint, Red....	King.....	Minneapolis..	5 ft. 6 in.	8 in.	8	Early dough
Dent, White.	Palouse.....	Wash. State..	2 ft. 9 in.	6 in.	10 to 14	Ripe
Dent, White.	Berg's.....	Mentor.....	5 ft. 3 in.	8 in.	12 to 16	Ripe
Dent, White.	Cooper's.....	St. Cloud.....	5 ft.	8 in.	10 to 14	Dented
Dent, White.	Golden Drop.....	Wisconsin.....	6 ft. 6 in.	9 in.	12 to 16	Partly dented
Dent, Yellow	Cooper's.....	St. Cloud.....	6 ft. 3 in.	7 in.	12 to 20	Slightly dented
Dent, Yellow	Minn. King.....	Minneapolis..	6 ft.	8 in.	8	Dough
Dent, Yellow	Dakota.....	Minneapolis..	6 ft.	8 in.	16	Milk
Dent, White.	Rustler.....	Minneapolis..	6 ft. 6 in.	8 in.	12 to 16	Early milk
Dent, Striped	Northwestern....	Bism'r'k, N.D.	6 ft. 9 in.	9 in.	12 to 16	Early milk
Dent, Yellow	Minn. No. 13.....	St. Anth'y P'k	6 ft. 6 in.	10 in.	12	Early milk

FORAGE CROPS.

PERENNIAL, MEADOWS AND PASTURES.

The hay crop will be for some time to come the most important money crop of the forest region. There is a constant demand for hay in winter to supply the lumbermen, and in most sections it commands a fair price. At present wild hay forms the bulk of the supply. It is obtained from natural meadows, sometimes of great extent, lying usually along water courses. Such hay requires only the cutting. Many meadows may be greatly improved at small expense, by clearing out brush and rubbish and by partial drainage.

Tame Hay.—As more land is cleared, tame hay will occupy a more important place. The first seeding done on a new farm is generally among the stumps either sown alone or with oats as a nurse crop. After a crop or two is removed the field is used for pasture, sometimes for a number of years. When the stumps are numerous and work is being done on other portions of the farm, this is sometimes the most profitable policy, but more often land is kept in grass when it should be broken and planted to other crops. Keeping one portion of a farm in pasture, while potatoes and oats are grown year after year upon the remaining fields, cannot be too strongly condemned. If, instead, the rotations outlined in a preceding portion of this bulletin be practiced, the yields of both hay and grain will be much increased. Upon Northeast Farm a large acreage is annually sown to grass. The sod is not allowed to lie more than two or three years. The first two crops of hay are much larger than succeeding crops would be and if the sod is then turned under it is of great benefit to the soil and the succeeding crops. Within two years the piece is again seeded. By this method about one-half of the farm is in grass each year. The grasses used most extensively for hay are timothy and red clover. There is no longer any question as to the possibility of growing red clover in the forest regions of Minnesota. During the four years in which clover has been grown

on Northeast Farm there has been but one failure, which was caused by winter killing in the winter of '97 and '98. During this season the ground was bare nearly all winter. The deep snow of an ordinary winter furnishes the best possible protection to the clover. Clover and timothy have been usually sown together, with oats as a nurse crop. The seed was sown after the oats with a Thompson wheelbarrow seeder, which sows, broadcast on the surface. This method is comparable with hand sowing, but distributes the seed more evenly and is not seriously interrupted by wind. The seed was dragged in with a light slant-tooth harrow, to cover lightly. Except where sown on new ground to increase the pasture, grass seed should not be sown alone. Less seed is required, but except under very favorable circumstances, no crop is produced until the second year, and weeds are apt to be troublesome. A grain crop as a nurse crop keeps down the weeds, produces a profitable crop on the land for that year and by its early removal gives the grass time to grow in the fall and produce a full hay crop the following year. Wheat and barley when grown as nurse crops do not shade the ground so densely, nor remove so much moisture as oats, and thus give the grass a better chance. The new grass should never be pastured in the fall of the year in which it is seeded. The young and tender plants are so seriously injured by cropping and treading that the prospects for the following year may be completely ruined and in many cases fall pasturing will heavily reduce the yield. Different amounts of seed have been sown, varying from ten pounds each of clover and timothy per acre, to five pounds of clover and eight pounds of timothy. If uniformly sown six pounds of clover and nine pounds of timothy will give a stand sufficiently thick. This will be one part clover and two of timothy by measure sown mixed together at the rate of nine quarts per acre.

The first seeding on the farm was in '96, on a field that had been in potatoes for three years. This field is the poorest soil on the farm. In '97 a crop of clover was cut from it which averaged 2.3 tons per acre. The second crop of clover was cut the same

year and yielded nearly a ton. On the following year the yield was largely timothy and as the sod had been injured by the severe exposure of the winter, the yield was light. This sod was turned under in the fall of '98, and in '99 bore oats and was again seeded down. The stand of grass in the fall of '99 was nearly perfect. In a field seeded in '97 the clover was killed out the same winter, but the timothy yielded a fair crop in '98, and was pastured during the summer of '99 and plowed up in the fall. About 25 acres was seeded in '98. Most of this ground had never been seeded to clover before. It was noticed that on the newest land the clover did not flourish evenly for the first crop, but still grew in sufficient quantity to make up at least one-half of the hay. The second crop of clover on this same land made a very fine, even growth. On the older fields, although never sown to clover previously, the stand was even and heavy for both crops of clover. On one such field of 3.25 acres, sown with wheat in '98, the first crop yielded 9.55 tons, or 2.94 tons per acre. The second crop was cut, yielding 3.87 tons or 1.19 tons per acre, making a total per acre of 4.13 tons. From the new land, seeded with oats, on which the stand was about one-half timothy, 36.15 tons were cut from 11.8 acres, giving a yield of 3.06 tons per acre.

The second crop of clover on a portion of this field was plowed under, that the land might be used the following year for some experiments for which level ground was needed. The remainder was pastured in the fall. It may not always be advisable to cut the second crop of clover for hay. Great difficulty may be experienced in curing it. Probably the most profitable use for it is as a fall pasture. The clover is a biennial plant and bears its crop the second year after seeding. It is only propagated after this by seed. If the second crop is allowed to go to seed on the ground the clover will be perpetuated. Otherwise the crop of the following year will be largely timothy. Comparative tests have been made of other grasses for their adaptability to light soils. These tests have shown that both red and alsike clover will do better on such soil than the true grasses. Alsike clover is slightly better adapted to heavy, wet soils than red clover, and

will make good growth, in partially drained soils where red clover will be injured by water. On ordinary soils red clover is much superior in stand, yield and aftermath to alsike. Of the grasses *Bromus Inermis* gave best results on light soil. This grass is a new species imported from Russia, and is coming into general use in some parts, being well able to stand droughts and cold. It may prove valuable for sandy soils, but should be tried on a small scale first. Red top is best suited to moist soil conditions, and did not do as well as timothy in this test. Orchard grass is not valuable, giving almost no yield. Alfalfa was not able to stand the winter, and probably cannot be grown this far to the northeast. Much work remains to be done in testing grasses.

ANNUAL FORAGE CROPS.

In live stock farming dependence cannot always be placed on the hay crop to furnish all the forage necessary for wintering over the stock. Should the hay crop fail or be light, the farmer's chief reliance is raising a crop of forage which requires but one season for growth. Some kinds of forage, such as fodder corn, are grown so cheaply and in such quantities, that they should be extensively grown and fed as a substitute for hay.

The principal classes for forage experimented with have been the millets, sorghum and corn. Millet furnishes a good quantity of hay. It was found to do best on rather heavy soil. Its best use is as a catch crop after a failure of some early crop or as a late crop on new land. Millet sown as late as July 1st has produced a fair crop of hay on Northeast Farm, but it should ordinarily be sown by the middle of June. It must not be sown in spring much earlier than the latter part of May, since like the corn the seeds will rot in a cold, damp soil. The hay should be cut before the heads are all out. If too ripe the seed is indigestible and dangerous to feed. Of the varieties tested those most suitable for hay were the Common, Hungarian, Golden and German Millet. They yielded between 1.5 and 2.5 tons per acre. Common millet is somewhat earlier

than the others, and is the best variety for very late seeding. "Broom Corn" millet, or "Hog" millet, is coarser in stalk, produces a larger yield of forage, and will give a heavy crop of seed which can be used for hog or chicken feed. It does better than the others in wet places.

Sorghum, and the similar fodder plants, Kaffir corn, Jerusalem corn, and Dhoura, have been grown to compare them with corn. The tests have indicated that for this latitude none of these plants are equal to corn in ease of growing and amount of fodder produced. They are all accustomed to a warmer climate than corn and cannot be planted as soon in the spring. They do not mature sufficiently before frost to yield the maximum crop, and the fodder being immature does not make as good feed. Their use is not recommended in place of fodder corn.

For winter forage, as a substitute for hay, fodder corn stands easily first. If properly cut and cured it is sweet and palatable and stock relish it. The yield per acre of cured fodder is between three and four times as great as hay, and although corn does not contain the same, nor as valuable food products as clover hay, yet, the much greater yield more than makes up for this, and the actual value of the fodder from an acre may be double that of clover hay.

By the growth of fodder corn a small farm may be made to support half again as many cows as could be carried along on other crops. Fodder corn has always been one of the staple crops on the Northeast farm. In the winter of 1898 and 1899 it was the only fodder fed to cows. Fed with a proper proportion of bran, to make a balanced ration, the fodder corn raised on a field of three and one-half acres, supported six milch cows for five months. Fodder from this same field was fed in addition twice a day, for the same period, to a flock of fifty sheep, whose only other rough feed was straw. The corn in this case was run through a feed cutter and none was wasted. If fed whole there will be some waste.

The growing of fodder corn aids in establishing a good rotation of crops. It responds to fertilizers more readily than any

other crop and thus furnishes the best opportunity in the rotation for applying manure. If cultivated well, it cleans the surface soil of weeds. The varieties of corn grown for fodder at the Farm, are the leafy dent kinds which ripen in the southern part of the state. These kinds are more suitable for fodder here, than those advertised in seed catalogues as fodder or ensilage corn, which are apt to be too slow in maturing for our climate and too coarse for the best grade of fodder. Southern Minnesota dent corn will mature sufficiently for fodder much farther north than Grand Rapids. The seed will not ripen here and must be imported each year. The results of experiment have shown that it is better to plant corn for fodder in drills rather than to broadcast it. Broadcasted corn stands so thick that the moisture supply may be exhausted before proper growth is made. The corn on the farm is now sown in drills, far enough apart to admit of cultivation between them. Last season it was planted with the grain drill by plugging up all the holes but those desired. Double rows of corn were sown six inches apart with a space between each double row of thirty-six inches. One bushel of corn per acre was needed when sown in this way. This gave a stand thick enough to prevent the formation of large stalks which the cattle waste when thrown to them whole. The corn was sown June 9th. It should not be sown much earlier than this for fodder. It was cut between the 10th and 20th of September. To secure the best fodder, corn should be left until it has begun to mature, as indicated by the lower leaves beginning to turn yellow. Frost injures the quality and palatability of the fodder. If planted the second week of June it should be fit to cut about the first week in September, when it will generally escape all injury from frost. It should be cut and shocked in medium-sized shocks. It has been found practical to cut fodder corn planted in double rows by horse power, by using the low sled so generally adapted in other sections. This sled is a V-shaped platform of boards mounted on 2x6 plank runners. Knives made from old saw blades are set along each edge at an angle of sixty degrees with the front. A single horse draws the sled, walking between two rows, which are

cut off by the knives. Two men riding on this sled catch the corn, and stopping the horse for every armful, set it up in shocks. This method saves over half the time in cutting. It is more difficult to build good shocks, but on the whole is probably a better method than hand-cutting. The efficient, but expensive, corn binder, which cuts and binds the corn stalks into small bundles, will not be used for some time, except in the older and better-developed communities. The corn at the Northeast Farm, after standing about six weeks, was re-shocked, putting three shocks into one. By this method the corn was first allowed to cure well, and then by increasing the size of the shocks it was given better protection from the weather. It stood in the field in these shocks all winter, being hauled up, cut and fed, as needed. Unless tied in small bundles and stacked after thorough curing, this is probably the easiest way of handling it. The yield in 1898 was about seven tons of cured fodder per acre.

In new sections where roads are poor and it is not possible to get grain threshed, it is customary to cut the oat crop and feed it whole. When this is done the crop should be cut earlier than for grain. If the oats are cut when the grain is in the milk nearly as much food will be secured as at any later period, as at this time it is evenly distributed throughout the plant, making a palatable food of the stalks, which later on, with the ripening of the grain, becomes straw.

Peas are sometimes sown with the oats for hay, but under our conditions the oats are apt to crowd them out, and they should generally be sown by themselves, or with a very small quantity of oats, one or two pecks per acre, to support them.

ANNUAL PASTURE CROPS.

To furnish pasture for animals it is sometimes necessary on farms that are heavily stocked, or where conditions of drought prevail in summer, to grow crops to supplement the grass pastures at certain seasons. While it may be difficult to spare land for such a purpose, yet the great abundance of pasture provided by some of these crops on a small space may make it profitable to devote a portion of the farm to such uses.

The experiment work, so far, has been with winter rye, corn, sorghum, rape, oats and peas. Actual tests were made of these crops by pasturing animals upon them to obtain some idea of the amount of pasture they would furnish. Cows waste too much by trampling; but sheep may be pastured on any crop and will consume it without waste, and hogs may be pastured on rye, peas and rape with great profit. In supplying such additional summer food to cows, and in some cases to hogs, it may be found more satisfactory to cut and feed it to them. This requires additional work, but greatly increases the amount of food secured from a small acreage.

Winter rye was sown about September 1. If sown much later than this it does not have time to prepare for winter and will not make a good growth in the spring. Its best use is as an early spring pasture. It comes on two to three weeks earlier than grass, and if kept cropped reasonably close, may be pastured for six or seven weeks. If not pastured it will make a good crop of hay by cutting early, or may be left for a grain crop. Rye will grow well on any soil. Oats and peas sown together for pasture furnished as much food as rye, but were not ready for pasturing until about the middle of June. Corn was sown broadcast, and furnished a large amount of food in July and August. When bitten off it does not sprout again, and pasturing with cows is not the most economical use to put it to, but for a soiling crop to be cut and fed in these months it is superior to all others. Sorghum and Kaffir corn sprout quickly when eaten off, and for a hot-weather pasture especially for sheep, may have a place in our farm economy.

Rape is a plant allied to cabbage, but whose foliage resembles that of turnips. It will produce a great quantity of fodder under favorable conditions, and is especially valuable for a late fall pasture for sheep. It resists light frosts easily. This plant grows on muck soils, but must have good drainage. The sand vetch and spring vetch have been grown, but have not given as good results for pasture crops as any of the other crops. They will thrive on very sandy soil and improve its condition.

POTATOES.

The soils of this section are well adapted to growing potatoes, the quality of which is unsurpassed. The potatoes grown in the Chisago district have won a wide reputation. The crop is an important one to the settler, as it gives large returns from a small acreage. Upon new ground, or where wise rotations have been practiced, the yield of potatoes will ordinarily average over 200 bushels and very much larger yields have been reported. The work of Northeast Farm has been to test different varieties for yield and adaptability. Fourteen kinds have been grown for three years, and many more will be tested in the future.

TABLE VI.—Potatoes Yields for Three Years.

Variety	1896 Bu. per Acre.	1897 Bu. per Acre.	1898 Bu. per Acre.	Average for 3 trials Bu. per Acre.
American Wonder.....	347.0	184.3	250.0	260.4
Prize Taker.....	343.0	177.6	239.0	253.2
Carmen No. 3.....	316.0	171.5	261.3	249.8
Carmen No. 1.....	277.0	198.4	180.0	239.6
Freeman.....	320.0	150.1	213.5	227.9
Irish Daisy.....	289.0	195.1	191.7	225.3
Irish Cobbler.....	312.0	141.0	217.1	223.4
Rural Blush.....	273.0	169.9	219.8	220.9
New Queen.....	257.0	211.2	193.4	220.5
Early Ohio.....	246.0	223.3	165.6	211.6
Acme.....	280.0	139.1	201.6	206.6
Good News.....	296.0	175.4	146.8	206.1
World's Fair.....	289.0	90.9	158.7	179.5
Maggie Murphy.....		214.4	251.5	
White Elephant.....		222.2	165.1	
Burbank.....		227.7		

The American Wonder has given the heaviest average yield, and is a medium-sized, good marketable potato. It gives rather more culls than some other varieties. Maggie Murphy is a large

yielder, but grows too great in size, and is not as good a table variety as others. Carmen No. 3 and Carmen No. 1, both smooth, white potatoes, gave the most uniform yield of marketable tubers. No. 3 is a trifle too late in ripening for best results. Burbank yields well and is readily marketed, but is somewhat late. Of the early kinds raised the Early Ohio is popular. It keeps well, and is excellent for the table, although apt to grow hollow. The Acme, a variety somewhat resembling it, is nearly as early and a good yielder. It has not been found advisable to plant potatoes before June 1st. Late varieties, as Carmen No. 3, will not always ripen thoroughly before Oct. 1st. In an average season they should be dug between the 1st and 10th of October. When intended for storage and spring markets, it is probably more advisable to grow a second early kind if it is a good yielder. The Early Fortune has been grown quite largely about Grand Rapids, and is recommended.

If potatoes are grown on the same soil year after year they will soon exhaust its fertility, and scab is almost sure to make its appearance. Scab is a fungus which lives upon the potato. It is never present in new soil, and must always be brought into it by planting scabby potatoes. Even if scabby seed is planted in new soil, the first crop is comparatively free from scab, as it seems to take a year or two for scab introduced in this way into new soil to multiply sufficiently to affect the crop. Once introduced it is only a question of time until the ground is so infected with scab that potatoes can no longer be grown there. This is the reason that clean seed when planted in such ground will produce a scabby crop. Scab will live in the ground for several years, and the only way to kill it is to avoid planting potatoes on it for a number of years. To avoid scab altogether, clean seed must always be planted in clean ground. If clean seed cannot be had, scabby seed may be treated in such a way as to kill the scab. To do this soak the whole potatoes in a solution of corrosive sublimate for an hour before planting. Two ounces corrosive sublimate dissolved in a small quantity of water and diluted to eight gallons will give the proper strength.

VEGETABLES.

It is safe to say that nowhere in Minnesota can vegetables be grown superior in size and quality to those produced in Northeast Minnesota. Northeast Farm has grown nearly every known kind of vegetable and annually tests many different varieties in the garden. As there is no difficulty in growing any of the common vegetables, as peas, beans, beets, sweet corn, onions, etc., the catalogues of reliable seedsmen are the best available guides as to varieties to choose, and individual taste will have to decide the matter. The shortness of the season makes it necessary to take especial care of tomatoes, in order to enable them to ripen before the frost. Dwarf Champion, Stone, Honor Bright, Early Minnesota, and Acme, are recommended as being early and prolific. The season is rather short for melons, though with good care the early varieties of musk melons can be ripened. Early Netted Green, Emerald Green, and Jenny Lind are good varieties for trial. A small variety of watermelon, the Hungarian Honey, will ripen here, and possibly others. Hubbard squash ripens, but requires good care. To better carry on the work in gardening, the Farm has constructed a hot-bed, in the form of a green house, with an alley and beds on each side, the whole covered with sash. This is heated by a layer of rotting manure 3 feet deep, upon which is placed six inches of dirt. This simple structure makes it possible to start tomato, cabbage, and cauliflower, and even melon plants quite early in the spring. Raddishes and lettuce have been raised in it and matured before the seeds planted outdoors had germinated. By giving melon plants an early start, and moving them out doors before they are grown enough to set them back, the chances of a good crop are materially increased. A few tomato plants were left in the house all summer and by covering them with the sash in the fall the period of ripening was extended considerably.

SMALL FRUITS.

STRAWBERRIES.

Strawberries are grown successfully on the Northeast Farm. Yields of 3,000 quarts per acre have been obtained. The ground selected is rather moist. It is well manured with rotted stable manure plowed in. A new bed is set out each year in the spring and the plants are taken from the bed set out the year previous, before they have ever borne fruit. They are planted in rows four to five feet wide, leaving two-foot spaces between plants. The rows are cultivated one way the first year, and the runners allowed to grow at will, and form a matted row of plants. No fruit is allowed to set the first year. The main crop is borne the second year. The bed may be saved for another crop by plowing under most of the vines, leaving strips from which the runners may spread and renew the patch. The bed is covered in the fall after the ground freezes, with a layer of straw three inches deep. This is left on in the spring as long as possible, which is until the plants start to grow strongly. By thus delaying the start, danger of frost on the blossoms is averted. The straw is then raked off the rows and left on the ground between them. This keeps down the weeds and prevents the ground from drying out when the berries are ripening. Bare, exposed soil at this time will result in a small crop of ill-formed berries. This is the reason why some have found that berries sometimes yield better in grass and weeds than on ground kept clean. It is naturally better to substitute straw for the weeds. Berries raised in this way will ripen here between the 1st and 15th of July, at which time they will bring a good price. Some of the best varieties of strawberries have imperfect flowers, lacking the stamens, or male organs. If these kinds only are raised they will produce no berries. They must be planted in alternate rows with a perfect-flowering variety. Varieties with perfect flowers, if planted alone will produce the usual crop. The varieties used on Northeast Farm were Haverland, Warfield and

Crescent, all imperfect or pistillate, with Bederwood, a perfect-flowering or staminate variety, in alternate rows. Many others of the best varieties will come into bearing in 1900.

RASPBERRIES.

A plantation of 600 raspberries was set out in '96 and more have been added since. High water injured one-half of these plants and the open winter of '97 and '98 killed back a part of them, but the crop of berries borne in 1899 was very satisfactory. If given proper winter protection the hardier varieties of red and black raspberries can easily be grown here with complete success. The bushes are bent over in the fall by loosening the dirt on one side and bending them in the root, till they lie under the ground. They are then covered with earth to a depth of three inches and left until they start in the spring. The varieties proved to be hardy by trial at the Farm are:

Red—Hardest, Turner, Marlboro; second hardy, Columbia.

Black Caps—Hardest, Older, Nemaha; second hardy, Ohio.

The kinds more recently set out have not been tested long enough as yet to report upon.

Blackberries—two varieties, the Snyder and Ancient Briton—are being grown. The bushes must be laid down in the same manner as the raspberries. To try to bend the canes will be apt to result in injury. The Snyder is the earlier variety. Both these varieties bore fair crops of berries in '99, and promise to do well in the future.

Gooseberries are perfectly hardy. The varieties grown are the Houghton and Downing. The Juneberry and Sand Cherry, while not particularly valuable, grow readily anywhere. Currants have been only moderately successful.

ORCHARD FRUITS.

Some years ago it was not thought possible to grow apples in the northern half of the state, but with the improvement in varieties the northern limit of growth is retreating. Grand Rapids may be considered at present as being very nearly the most northerly point at which apples can be grown. It is therefore well suited for testing the possibilities of new varieties for hardiness. The orchard is now three years old. The trees were heeled in the first winter and set out in the present orchard in the spring of '98. The winter of '98 and '99 following was a very severe one, and some varieties were badly injured. The trees were protected by mulch and the trunks were wrapped with burlap to prevent sunscalding in the early spring.

Those varieties of crabs and apples that survived the winter without injury are recommended as being perfectly hardy. Some of the others may succeed if given a better start before being subjected to such trying conditions. The varieties found to be hardy are:

Crabapples—Martha and Virginia.

Apples—Silken Leaf, Christmas.

Duchess and Hibernial were badly injured, but some trees lived through and may survive.

Early Strawberry Crab, Ostrakoff and Dart's are probably not hardy enough for the climate.

PLUMS.

An orchard of over 100 hundred plum trees was set out in '99. These include many new and superior varieties. It is thought that these plums will be perfectly hardy as many native plums grow much further north than this.

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